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HIGH SPEED AERODYNAMIC CHARACTERISTICS OF THE GAFØPH AEROFOIL

by

B. D. FAIRLIE

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B. D. FAIRLIE

SUMMARY

Transonic wind tunnel tests are reported on a two-dimensional model of the GAFOPH aerofoil. The tests covered Mach numbers in the range 0·5 to 0·85 and angles of incidence from −3° to above maximum lift coefficient. Tests were conducted both with natural transition and with transition artificially fixed. Maximum lift coefficient was found to lie just below 0·8 for most of the Mach number range and was followed by a fairly gentle stall. Drag rise Mach number was found to lie between 0·75 and 0·76 for lift coefficients up to 0·4. A leading edge separation bubble was found on the upper surface of the aerofoil for angles of incidence greater than 2½°.

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16. *ABSTRACT*

Transonic wind tunnel tests are reported on a two-dimensional model of the GAF0PH aerofoil. The tests covered Mach numbers in the range 0·5 to 0·85 and angles of incidence from −3° to above maximum lift coefficient. Tests were conducted both with natural transition and with transition artificially fixed. Maximum lift coefficient was found to lie just below 0·8 for most of the Mach number range and was followed by a fairly gentle stall. Drag rise Mach number was found to lie between 0·75 and 0·76 for lift coefficients up to 0·4. A leading edge separation bubble was found on the upper surface of the aerofoil for angles of incidence greater than 2½°.

CONTENTS

NOTATION

A	Area of aerofoil section in $x - z$ plane.
b	Breadth of tunnel.
C_D	Drag coefficient = (drag force)/qS.
C_L	Lift coefficient = (lift force)/qS.
C_m	Pitching moment coefficient = (pitching moment about $c/4$)/qSc.
c	Aerofoil chord (see 2.1).
E	Universal empirical blockage factor.
G	Ratio of corrected to uncorrected kinetic pressure.
H	Free stream total pressure.
h	Height of tunnel.
M	Free stream Mach number.
p_0	Free stream static pressure.
q	Free stream kinetic pressure = $\gamma/2\, p_0\, M^2$.
Re	Reynolds number based on chord (c).
S	Aerofoil area ($b \times c$).
t	Aerofoil maximum thickness.
U	Free stream velocity.
x	Chordwise coordinate, origin at leading edge.
y	Spanwise coordinate, origin at mid-span.
z	Aerofoil thickness coordinate, origin at chord line.
α	Angle of incidence.
β	Prandtl-Glauert compressibility factor = $(1 - M^2)^{1/2}$.
γ	Ratio of specific heats, taken to be 1.4.
δ_0	Lift interference parameter associated with stream direction.
δ_1	Lift interference parameter associated with stream line curvature.

Subscripts

f	Denotes free-air (corrected) values.
0	Denotes zero lift value.

1. INTRODUCTION

At the request of the Aircraft Industry Study Group, (A.I.S.G.), transonic wind-tunnel tests have been carried out on a two-dimensional aerofoil section denoted GAF0PH. The tests covered Mach numbers in the range 0·5 to 0·85 and angles of incidence from below zero lift to above stall. Measurements included three components of forces and moments (lift, drag and pitching moment) and the determination of buffet boundaries. The tests were conducted during December 1979 and January 1980.

2. TEST DETAILS

2.1 Section Definition

The ordinates of the aerofoil section are presented in Table 1. These ordinates are identical with those supplied by the A.I.S.G. except in the vicinity of the trailing edge. To obtain a practical shape for manufacture, the trailing edge was cropped to give a trailing edge thickness of 0·10 mm ($z/c = 0{\cdot}0007$). This was attained by ending the section at $x/c = 0{\cdot}997$ rather than continuing to the sharp trailing edge at $x/c = 1.000$. All aerodynamic coefficients are however based on the full theoretical chord (c).

2.2 Model Details and Accuracy

Studies of wind tunnel wall interference in the A.R.L. transonic tunnel have indicated that for two-dimensional aerofoil tests at subsonic speeds, the largest model for which interference corrections can be confidently applied has a chord of 150 mm. This chord length, which gives a value of chord to tunnel height ratio of 0·185, was found to be the largest which avoids the appearance of uncorrectable streamline curvature effects.

Based on these considerations, a model of GAF0PH was manufactured with a theoretical chord of 150 mm. The model was cast in epoxy resin over a steel spine using a development of the wax mould technique described in Reference 2. Measured profile errors for the completed model are plotted in Figure 1. Overall dimensional errors are generally within $\pm 0{\cdot}075$ mm ($\pm 0{\cdot}0005$ c) and local waviness is well within the usual tolerances.

2.3 Wind Tunnel

All tests were carried out in the ARL variable pressure transonic wind tunnel. The test section fitted for these tests had solid side walls and longitudinally slotted top and bottom walls (open area ratio 16·5% at the model location), with dimensions at the model location of $h = 813$ mm, $b = 533$ mm (Fig. 2). Mach number was derived from measurements of the pressure in the plenum chamber surrounding the test section, and in the entry to the contraction, assuming these to be the static and total pressures of the test section flow respectively.

The model completely spanned the width of the test section (apart from small gaps at each side wall) giving an aspect ratio of 3·05. It was supported by means of integral end tongues which extended through each sidewall. These tongues were mounted on a pair of three-component strain-gauge balances measuring lift, drag and pitching moment. To avoid air leakage through the sidewalls, each strain-gauge balance was housed in an airtight enclosure.

2.4 Measuring Equipment

Angles of incidence were derived from a digitizer driven directly from rotating frames in the side walls carrying the strain-gauge balances. To correct for stream angularity, the tunnel

stream direction was determined at the beginning of the tests from measurements with the model both upright and inverted. Strain gauge outputs were monitored by the tunnel A–C excited self balancing equipment.

All transducer outputs were processed by the tunnel PDP8/I computer data processing system. Angles of incidence were corrected for balance deflections, strain gauge outputs reduced to coefficient form (including correction for the effect of the weight of the model), and all outputs displayed and printed in real time. The data were also recorded on magnetic tape for further processing by the central site computer.

During the major part of the tests, buffet was detected from observation of the "flap" meters of the strain gauge equipment. These meters indicate the oscillatory component of each channel of strain gauge outputs by monitoring the average departure from nulled conditions.[3] An independent check was performed on this indication by replacing the A.C. excitation of the strain gauge balances with a D.C. source and displaying the resulting waveform on a cathode ray oscilloscope. In both cases, the pitching moment channel was found to give the most sensitive indication of buffet onset.

2.5 Transition Fixing

Tests were conducted both with natural transition and with transition fixed by spanwise bands of roughness particles. These roughness bands consisted of carborundum particles attached to both upper and lower surfaces of the model by a thin (0·03 mm) layer of lacquer. The bands were located at $x/c = 0{\cdot}05$ and were 0·015 c wide, with a particle coverage of 10–20%; particle size was 0·15 mm.

2.6 Test Programme

The test programme was as requested and was the same for both natural transition and transition fixed. Mach numbers were in the range $0{\cdot}5 \leqslant M \leqslant 0{\cdot}85$ at increments of 0·05. The range of angle of incidence was $-3° \leqslant \alpha \leqslant 11°$ at 1° increments. The maximum angle of incidence was varied somewhat with Mach number to ensure that the stall was adequately covered. Buffet boundaries were also determined for the complete range of Mach number.

The Reynolds number employed for these tests was chosen such that the maximum available Reynolds number was utilized at the highest Mach number (0·85), and approximately constant Reynolds number maintained for all other Mach numbers by adjusting tunnel starting pressures. Due to tunnel temperature variations during a run, the Reynolds number (based on chord) would vary slightly, the values being in the range $1{\cdot}20 \pm 0{\cdot}06 \times 10^6$. In addition, two representative runs were made at a Mach number of 0·55 to investigate the effects of varying Reynolds number; one at half the Reynolds number of the main body of tests ($0{\cdot}60 \times 10^6$), and the other at the maximum available Reynolds number ($1{\cdot}64 \times 10^6$) at that Mach number.

3. WIND TUNNEL WALL INTERFERENCE

The effect of wind tunnel wall interference on the subsonic testing of two-dimensional aerofoils in the A.R.L. transonic tunnel has been the subject of a detailed investigation reported in Reference 1. This report proposed a semi-empirical correction scheme which was shown to produce corrected results close to being free of interference effects, at least while the flow over the aerofoil remains attached. This scheme, which is summarized below, has been applied to all the present results.

Corrections to Mach number and angle of incidence are determined from

$$M_f = M + \Delta M$$

where

$$\Delta M = (1 + 0{\cdot}2\, M^2)\, \frac{EA_e}{\beta^3 h^2}$$

$$A_e = A\,(1 + 1{\cdot}2\beta\, t/c)$$

and E is a universal constant with a value [1] of $-1 \cdot 25$.

$$\alpha_f = \alpha + \Delta\alpha$$

where

$$\Delta\alpha = \left(\frac{c}{h}\right) \delta_0 C_L + \left(\frac{c}{h}\right)^2 \frac{\delta_1}{\beta} \left(\frac{C_L}{4} + C_m\right)$$

and δ_0 and δ_1 are lift interference parameters having values [1] of $-0 \cdot 16$ and $-0 \cdot 05$ respectively.

Corrections to measured quantities are then given by

$$C_{Lf} = (C_L + \Delta C_L)\, G$$

where

$$\Delta C_L = -\frac{\pi}{2}\left(\frac{c}{h}\right)^2 \frac{\delta_1}{\beta^2}$$

$$C_{mf} = (C_m + \Delta C_m)\, G$$

where

$$\Delta C_m = -\frac{\Delta C_L}{4}$$

and

$$C_{Df} = (C_D + \Delta C_D)\, G$$

where

$$\Delta C_D = \left(\frac{c}{h}\right) \delta_0 C_L^2$$

Note that G is the ratio of corrected to uncorrected kinetic pressure and is given by

$$G = \frac{1}{1 + (2 - M^2)\dfrac{EA_e}{\beta^3 h^2}}$$

It should also be noted that an extra term is usually included in the expression for ΔC_D to take account of longitudinal buoyancy forces experienced by the model due to longitudinal velocity gradients. However for a model of the chord length used in these tests, this term contributes less than $0 \cdot 2\%$ to drag and has therefore been ignored.

The results from tests both with and without transition fixed are tabulated in Appendix A. In each case, uncorrected as well as corrected values are presented.

4. RESULTS AND DISCUSSION

The variation of lift coefficient with incidence for tests both with and without transition fixing are presented in Figure 3. It should be noted that in this figure, as in all further figures, the corrected results are presented. It is apparent that the aerofoil exhibits a fairly gentle stall with maximum lift coefficients of about $0 \cdot 8$. For Mach numbers less than $0 \cdot 74$ the shape of the natural transition curves are consistently different from those with transition fixed. Up to an angle of incidence of approximately $2\frac{1}{4}°$, the natural transition curves show a significant increment in lift: for higher incidences the two curves have substantially similar shapes. This behaviour is consistent with the appearance in both cases of a laminar separation bubble close to the leading edge at an angle of incidence of $2\frac{1}{4}°$. Below this angle the natural transition case retains a laminar boundary layer for some distance downstream from the leading edge resulting in small increase in lift coefficient. This leading edge separation is visible in the flow visualization photographs of Figure 4, laminar separation occurring at about 1–2% chord with turbulent reattachment just upstream of the transition trip.

For the two highest Mach numbers, the natural transition curves are quite different from those with transition fixed. It seems likely that at these higher Mach numbers no leading edge bubble would form due to a reduction of the magnitude of the adverse pressure gradient. The natural transition curves will also exhibit nonlinearities due to laminar shock-wave/boundary-layer interactions.

In Figure 3 the positions of buffet boundaries are marked by vertical lines on each curve. These boundaries were derived from observations of oscillations in the pitching moment output channel of the strain gauge balances. Buffet boundaries for both natural transition and transition fixed cases agree quite closely. Figure 5 presents oscilloscope traces recorded from the pitching moment channel with the strain gauge balances excited from a D.C. source. The onset of buffet is quite distinct at the lower Mach numbers, being quite severe at $M = 0{\cdot}69$. At the two highest Mach numbers however, the buffet boundary is less clearly defined, the general level of background noise having risen quite distinctly.

The effect of Reynolds number on lift coefficient is presented in Figure 6. Over the range of Reynolds numbers investigated, this effect is quite small, the major differences being a slight increase in both lift curve slope and maximum lift coefficient with increasing Reynolds number.

The variation of lift curve slope (at zero lift) with Mach number is plotted in Figure 7. Despite the different characteristics exhibited by the natural transition curves at low incidence, the lift curves slopes for both natural transition and transition fixed are in good agreement.

Pitching moment coefficient is plotted against incidence in Figure 8 for natural transition and in Figure 9 for transition fixed. Once again the natural transition curves exhibit a discontinuity associated with the formation of the leading edge bubble at an incidence of $2\frac{1}{2}°$. At the highest Mach numbers the effect of shock wave—boundary-layer interaction is clearly visible. The variation of pitching moment coefficient with Mach number for the transition fixed case is presented in Figure 10.

Figure 11 presents the variation of drag coefficient with incidence. As would be expected, the natural transition case exhibits lower values of drag throughout most of the tested range due to the existence of a laminar boundary layer on the lower surface. When laminar boundary layers remain on both surfaces (before the leading edge bubble formation), the natural transition curves exhibit even lower drag values. At high Mach numbers however, the appearance of shock wave—laminar boundary layer interactions produce higher drags for the natural transition case. These effects are also clearly visible in Figure 12 which presents the variation of drag coefficient with Mach number. The drag rise Mach number (arbitrarily defined as the Mach number at which the drag has risen by $0{\cdot}002$ above its value at $M = 0{\cdot}5$) derived from these curves remains between $0{\cdot}75$ and $0{\cdot}76$ for values of lift coefficient up to $0{\cdot}40$. The effect of fixing transition on drag rise Mach number is quite small.

The effect of Reynolds number on drag coefficient is presented in Figure 13. Once again, over the range of Raynolds numbers considered, the effect is quite small. Values of zero lift drag for the transition fixed case are plotted against Reynolds number in Figure 14. Also plotted in this figure is the variation of the turbulent mean skin-friction drag coefficient on an insulated flat plate for the same Mach number ($0{\cdot}55$). The aerofoil results maintain a fairly constant increment above this curve, and this figure should thus allow an approximate extrapolation of zero-lift drag to flight Reynolds numbers.

5. CONCLUSIONS

Transonic wind tunnel tests have been conducted on a two-dimensional model of an aerofoil designated GAF0PH. The tests covered Mach numbers in the range $0{\cdot}5 \leqslant M \leqslant 0{\cdot}85$ and angles of incidence from $-3°$ to above maximum lift coefficient. Tests were conducted both with natural transition and with transition artificially fixed.

The results indicate that the aerofoil has a fairly gentle stall with a value of maximum lift coefficient just below $0{\cdot}8$ for most of the Mach number range. A leading edge separation bubble was found to exist on the upper surface of the aerofoil for angles of incidence greater than $2\frac{1}{2}°$. This separation bubble produced characteristic non-linearities in the behaviour of lift and pitching moment coefficients for the tests with natural transition. Drag rise Mach numbers were found to lie between $0{\cdot}75$ and $0{\cdot}76$ for values of lift coefficient up to $0{\cdot}4$.

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2. Collins, D. J.	An inexpensive technique for the fabrication of two-dimensional wind tunnel models. Rev. Sci. Inst. Vol. 44, 1973.
3. Pollock, N.	Operating and maintenance manual for Pollock-Lording strain gauge equipment. A.R.L.–Aero-Tech. Memo.–301, 1976.

TABLE 1

x (inches)	z upper (inches)	z lower (inches)	x (inches)	z upper (inches)	z lower (inches)
0·000000	0·000000	0·000000	0·726564	0·246486	−0·173202
0·000300	0·006528	−0·006438	0·754932	0·249984	−0·175974
0·001200	0·013194	−0·012846	0·783780	0·253428	−0·178806
0·002700	0·019992	−0·019218	0·813108	0·256812	−0·181698
0·004800	0·026886	−0·025524	0·842916	0·260136	−0·184650
0·007500	0·033846	−0·031752	0·873186	0·263400	−0·187674
0·010794	0·040848	−0·037878	0·903918	0·266598	−0·190758
0·014688	0·047856	−0·043878	0·935118	0·269724	−0·193914
0·019182	0·054846	−0·049740	0·966762	0·272784	−0·197136
0·024276	0·061788	−0·055434	0·998862	0·275778	−0·200430
0·029964	0·068652	−0·060942	1·031400	0·278700	−0·203796
0·036246	0·075396	−0·066240	1·064376	0·281550	−0·207228
0·043122	0·082002	−0·071304	1·097790	0·284322	−0·210732
0·050592	0·088434	−0·076110	1·131624	0·287028	−0·214308
0·058656	0·094650	−0·080640	1·165884	0·289662	−0·217944
0·067308	0·100632	−0·084870	1·200558	0·292218	−0·221610
0·076554	0·106380	−0·088818	1·235646	0·294708	−0·225282
0·086388	0·111900	−0·092496	1·271136	0·297132	−0·228948
0·096804	0·117204	−0·095922	1·307022	0·299484	−0·232578
0·107814	0·122310	−0·099120	1·343298	0·301770	−0·236154
0·119400	0·127236	−0·102114	1·379964	0·303984	−0·239664
0·131568	0·131994	−0·104922	1·417008	0·306138	−0·243090
0·144324	0·136608	−0·107580	1·454424	0·308226	−0·246408
0·157650	0·141096	−0·110100	1·492206	0·310248	−0·249612
0·171558	0·145476	−0·112512	1·530348	0·312204	−0·252690
0·186036	0·149760	−0·114840	1·568850	0·314100	−0·255624
0·201084	0·153972	−0·117102	1·607694	0·315930	−0·258396
0·216708	0·158124	−0·119316	1·646874	0·317700	−0·261006
0·232896	0·162240	−0·121506	1·686396	0·319410	−0·263442
0·249648	0·166326	−0·123690	1·726236	0·321054	−0·265686
0·266964	0·170382	−0·125874	1·766400	0·322644	−0·267738
0·284838	0·174408	−0·128052	1·806876	0·324168	−0·269580
0·303270	0·178410	−0·130230	1·847652	0·325638	−0·271212
0·322254	0·182376	−0·132414	1·888734	0·327048	−0·272622
0·341790	0·186318	−0·134610	1·930098	0·328398	−0·273804
0·361872	0·190236	−0·136818	1·971750	0·329688	−0·274752
0·382500	0·194130	−0·139038	2·013672	0·330924	−0·275460
0·403674	0·197994	−0·141276	2·055864	0·332106	−0·275922
0·425382	0·201846	−0·143538	2·098314	0·333228	−0·276132
0·447624	0·205674	−0·145824	2·141016	0·334290	−0·276102
0·470400	0·209484	−0·148134	2·183964	0·335268	−0·275838
0·493704	0·213276	−0·150468	2·227146	0·336150	−0·275346
0·517530	0·217056	−0·152838	2·270550	0·336936	−0·274638
0·541878	0·220818	−0·155238	2·314182	0·337608	−0·273726
0·566742	0·224568	−0·157674	2·358018	0·338154	−0·272616
0·592122	0·228306	−0·160146	2·402058	0·338574	−0·271326
0·618012	0·232014	−0·162660	2·446296	0·338856	−0·269862
0·644400	0·235692	−0·165216	2·490714	0·338988	−0·268224
0·671292	0·239334	−0·167826	2·535312	0·338976	−0·266436
0·698682	0·242934	−0·170484	2·580078	0·338808	−0·264498
			2·625000	0·338478	−0·262422

TABLE 1 (*Continued*)

x (inches)	z upper (inches)	z lower (inches)	x (inches)	z upper (inches)	z lower (inches)
2·670072	0·337986	−0·260208	4·890732	0·148548	−0·093480
2·715288	0·337326	−0·257880	4·929468	0·143556	−0·090246
2·760636	0·336498	−0·255426	4·967772	0·138606	−0·087042
2·806104	0·335508	−0·252870	5·005620	0·133692	−0·083874
2·851686	0·334338	−0·250218	5·043000	0·128814	−0·080748
2·897370	0·333000	−0·247464	5·079894	0·123984	−0·077652
2·943150	0·331494	−0·244626	5·116302	0·119208	−0·074598
2·989014	0·329814	−0·241704	5·152194	0·114474	−0·071586
3·034956	0·327966	−0·238710	5·187564	0·109800	−0·068616
3·080964	0·325944	−0·235644	5·222400	0·105186	−0·065688
3·127026	0·323754	−0·232518	5·256684	0·100632	−0·062802
3·173130	0·321402	−0·229332	5·290398	0·096138	−0·059964
3·219270	0·318882	−0·226086	5·323530	0·091716	−0·057174
3·265440	0·316200	−0·222798	5·356068	0·087360	−0·054432
3·311622	0·313356	−0·219463	5·388000	0·083082	−0·051744
3·357810	0·310356	−0·216090	5·419302	0·078876	−0·049104
3·403992	0·307200	−0·212676	5·449962	0·074754	−0·046518
3·450156	0·303894	−0·209238	5·479974	0·070710	−0·043986
3·496296	0·300438	−0·205764	5·509308	0·066750	−0·041508
3·542400	0·296838	−0·202272	5·537964	0·062880	−0·039084
3·588456	0·293100	−0·198750	5·565912	0·059094	−0·036726
3·634452	0·289218	−0·195216	5·593152	0·055410	−0·034422
3·680376	0·285210	−0·191670	5·619654	0·051816	−0·032184
3·726222	0·281082	−0·188106	5·645412	0·048318	−0·030006
3·771972	0·276834	−0·184530	5·670408	0·044922	−0·027894
3·817620	0·272490	−0·180948	5·694630	0·041634	−0·025842
3·863160	0·268044	−0·177360	5·718054	0·038448	−0·023862
3·908568	0·263514	−0·173766	5·740668	0·035370	−0·021948
3·953838	0·258906	−0·170166	5·762454	0·032406	−0·020106
3·998964	0·254220	−0·166572	5·783400	0·029550	−0·018336
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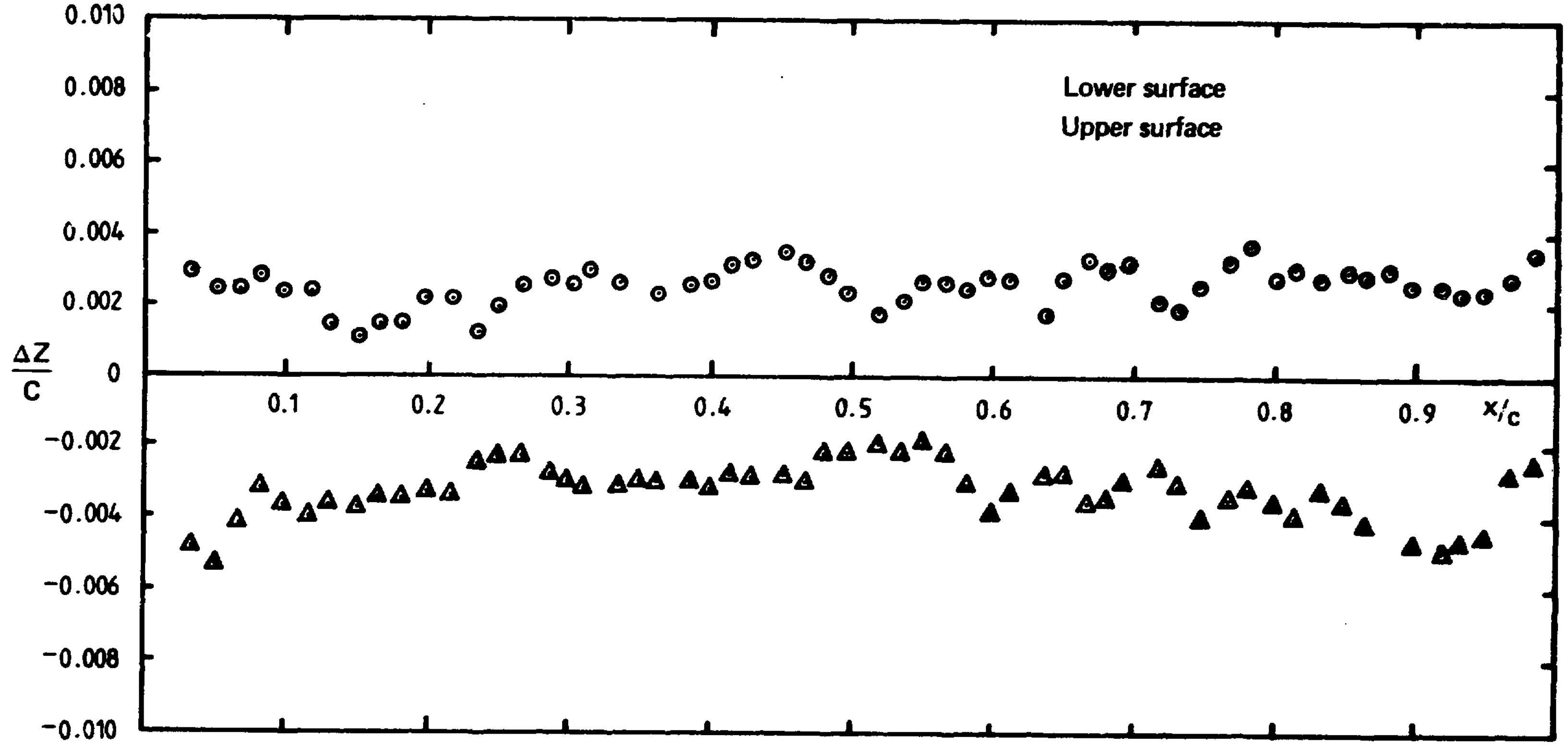
4·088718	0·244650	−0·159372	5·822700	0·024192	−0·015006
4·133322	0·239784	−0·155778	5·841024	0·021696	−0·013458
4·177734	0·234864	−0·152190	5·858442	0·019320	−0·011982
4·221936	0·229902	−0·148608	5·874936	0·017070	−0·010590
4·265916	0·224904	−0·145038	5·890488	0·014946	−0·009270
4·309668	0·219870	−0·141474	5·905086	0·012954	−0·008034
4·353174	0·214806	−0·137922	5·918706	0·011100	−0·006882
4·396422	0·209724	−0·134382	5·931336	0·009372	−0·005814
4·439400	0·204618	−0·130860	5·942964	0·007788	−0·004830
4·482096	0·199506	−0·127350	5·953560	0·006342	−0·003930
4·524498	0·194382	−0·123858	5·963118	0·005034	−0·003120
4·566594	0·189252	−0·120390	5·971620	0·003876	−0·002400
4·608366	0·184122	−0·116940	5·979042	0·002862	−0·001776
4·649808	0·178992	−0·113508	5·985372	0·001998	−0·001236
4·690908	0·173874	−0·110106	5·990592	0·001284	−0·000798
4·731642	0·168774	−0·106722	5·994678	0·000726	−0·000450
4·772004	0·163680	−0·103368	5·997624	0·000324	−0·000204
4·811982	0·158610	−0·100044	5·999406	0·000084	−0·000048
4·851564	0·153564	−0·096744	6·000000	0·000000	0·000000



ΔZ = Measured ordinate — Table 1 ordinate

FIG. 1 MODEL PROFILE ERRORS

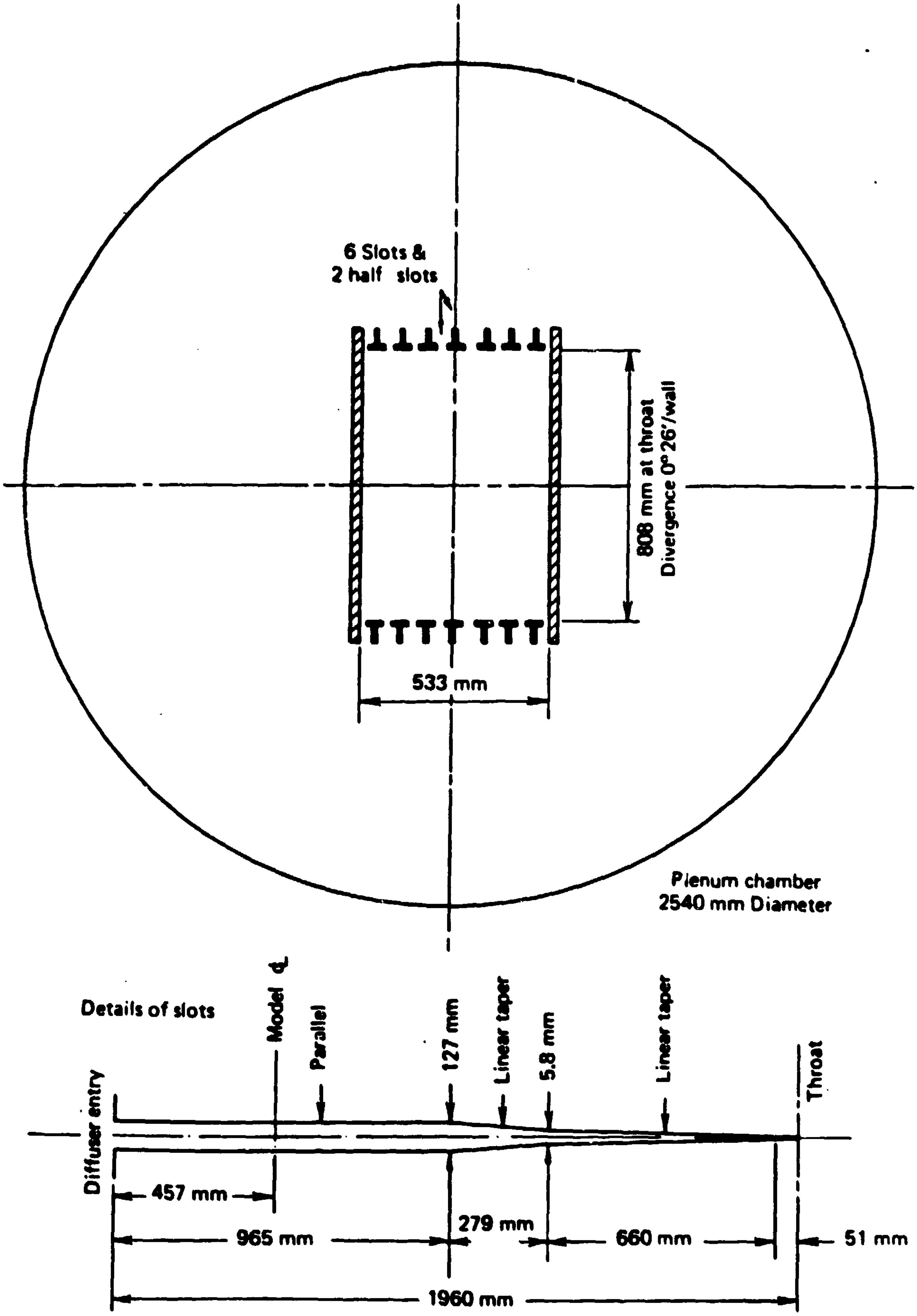
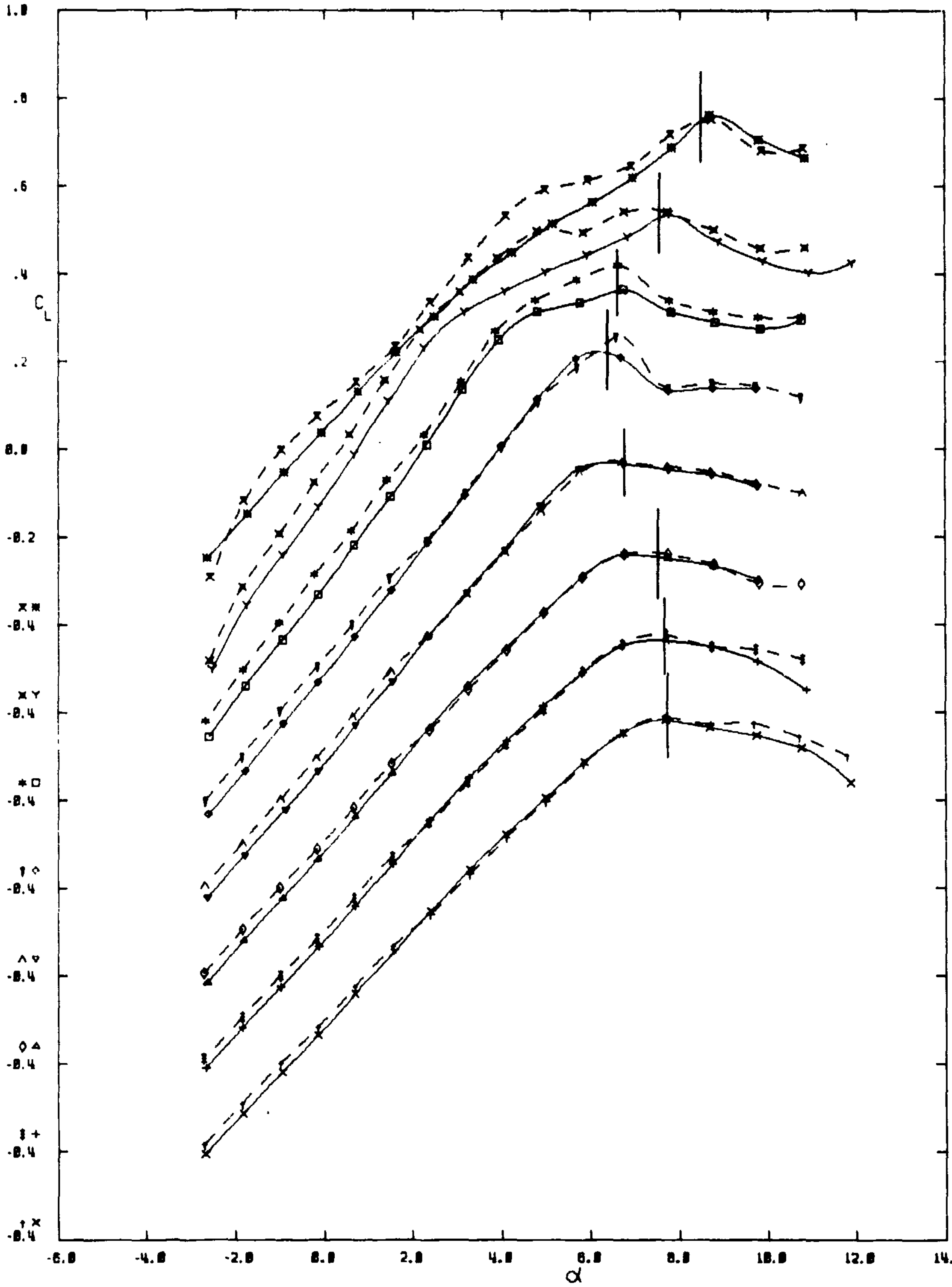
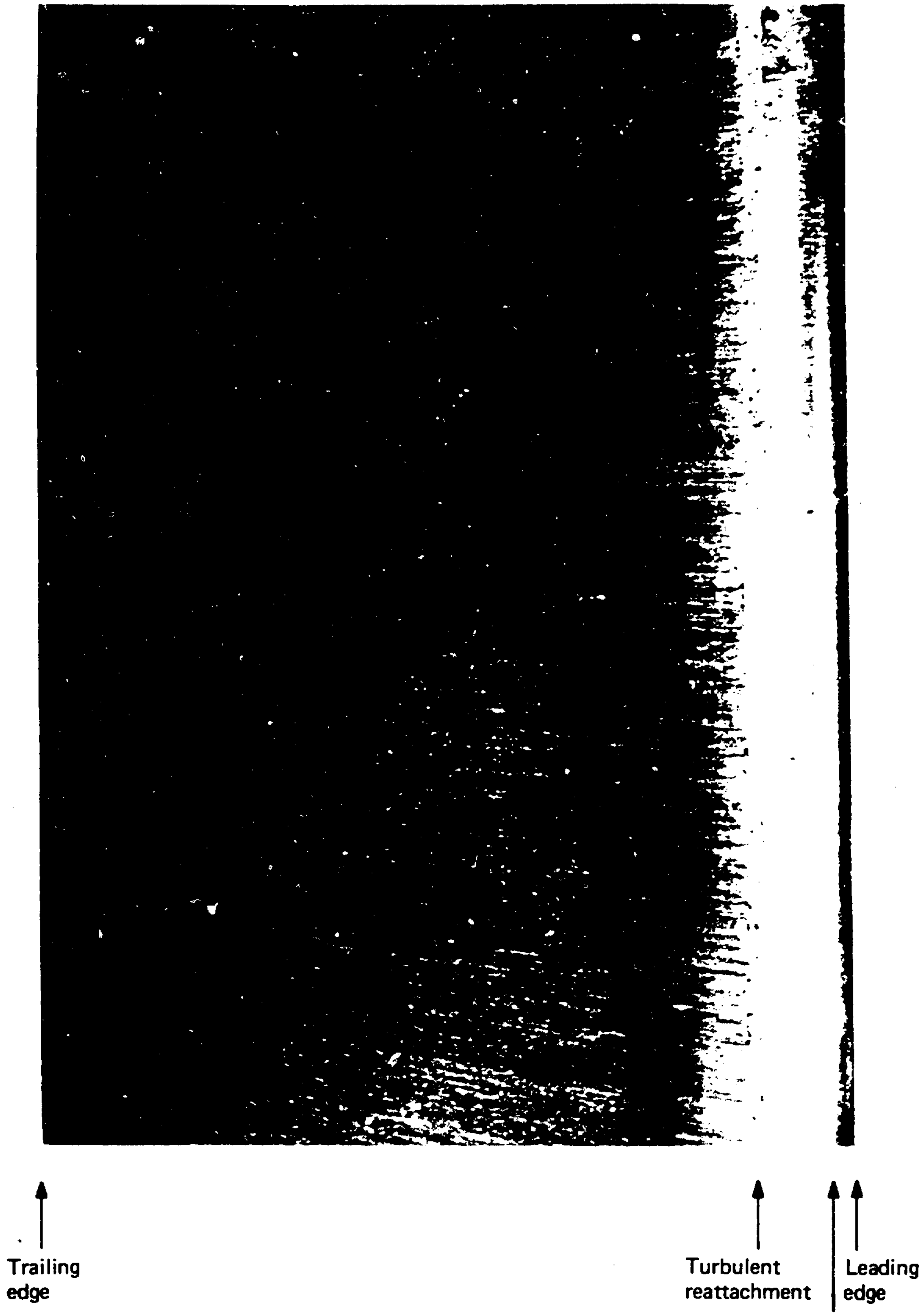


FIG. 2 DETAILS OF SLOTTED TEST SECTION



	SYMBOL	M		SYMBOL	M
TRANS. AT 5% ———	×	.49	TRANS. FREE — — —	†	.49
	+	.55		‡	.55
	▲	.59		◊	.59
	▼	.64		^	.64
	◆	.69		▼	.69
	□	.74		*	.74
	Y	.78		×	.78
	✱	.83		⨯	.83

FIG. 3 VARIATION OF LIFT COEFFICIENT WITH INCIDENCE: COMPARISON BETWEEN TRANSITION FIXED AND NATURAL TRANSITION



$M = 0.55 \quad \alpha = 2.8^\circ$

FIG. 4 SURFACE FLOW VISUALIZATION

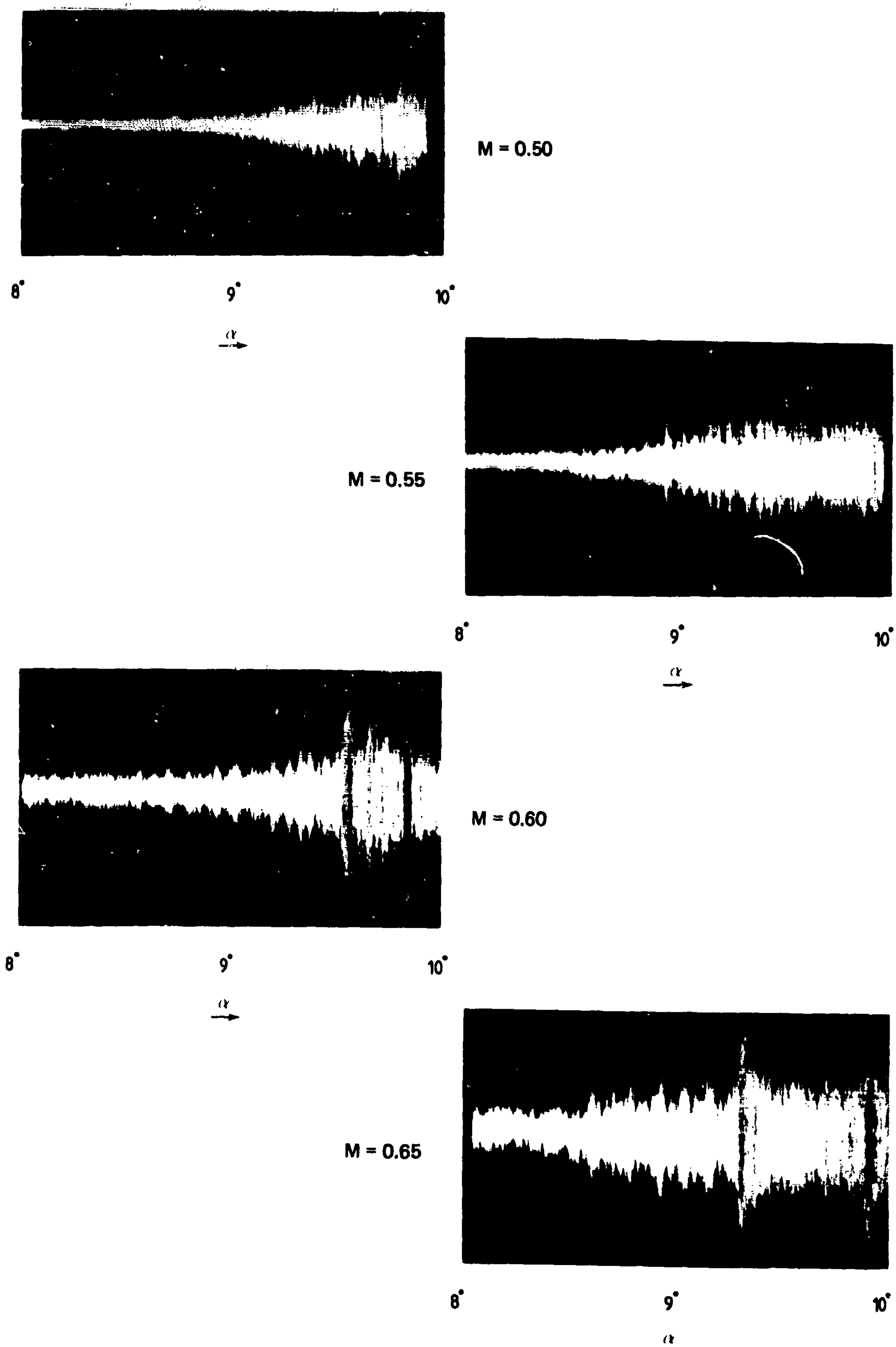


FIG. 5 BUFFET BOUNDARY OSCILLOSCOPE TRACES

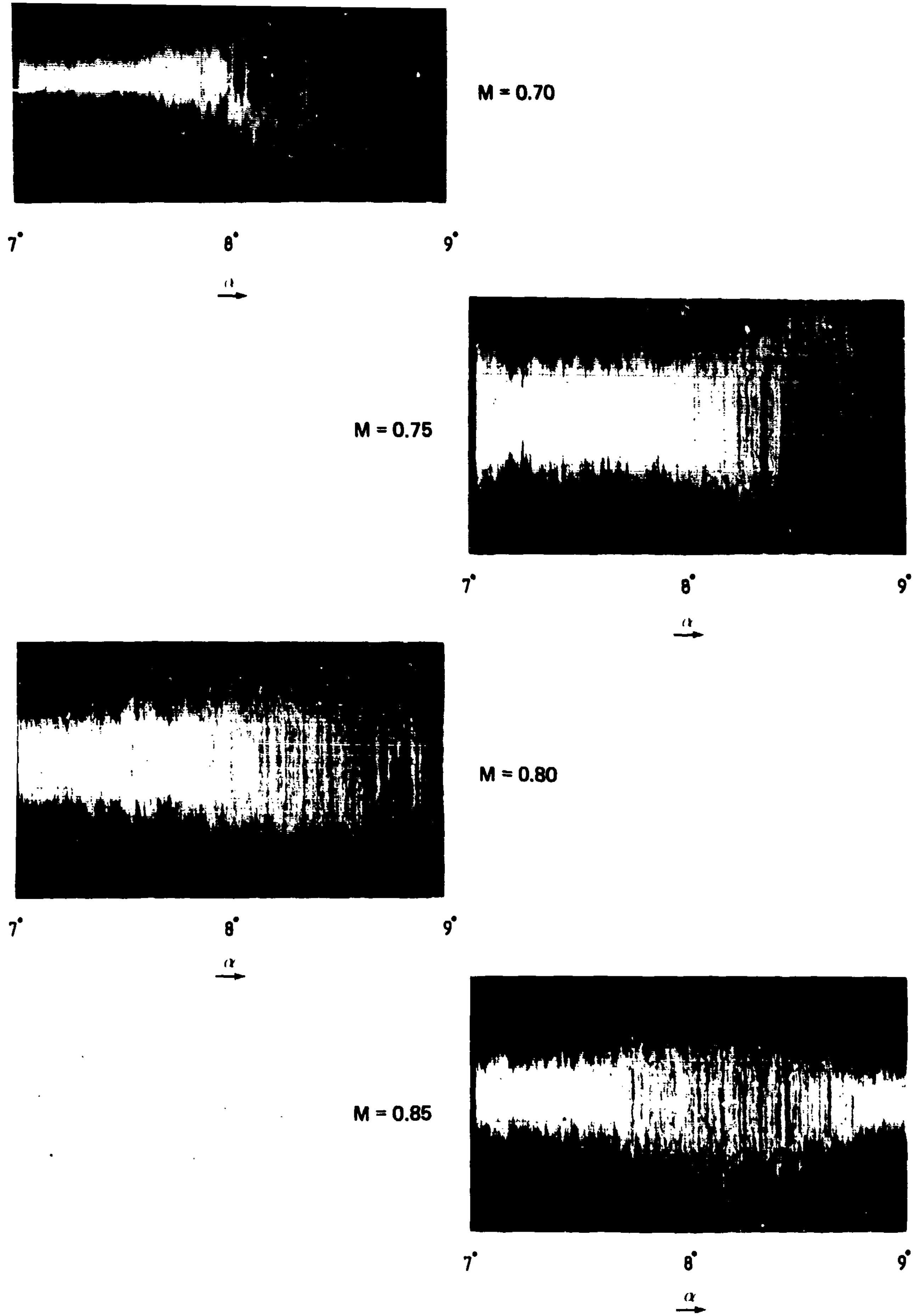


FIG. 5 (Cont.)

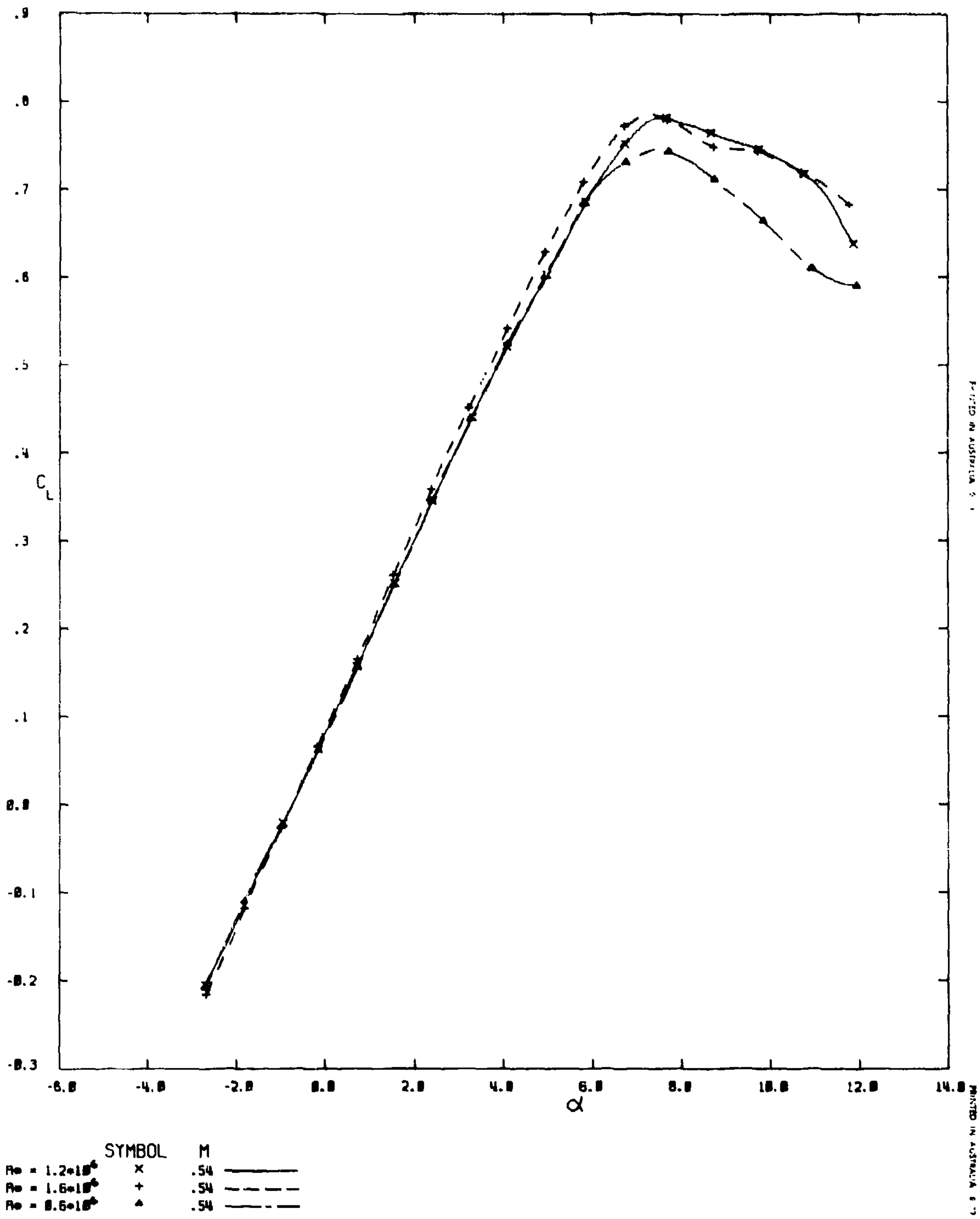


FIG. 6 EFFECT OF REYNOLDS NUMBER ON LIFT COEFFICIENT TRANSITION FIXED AT 5% CHORD

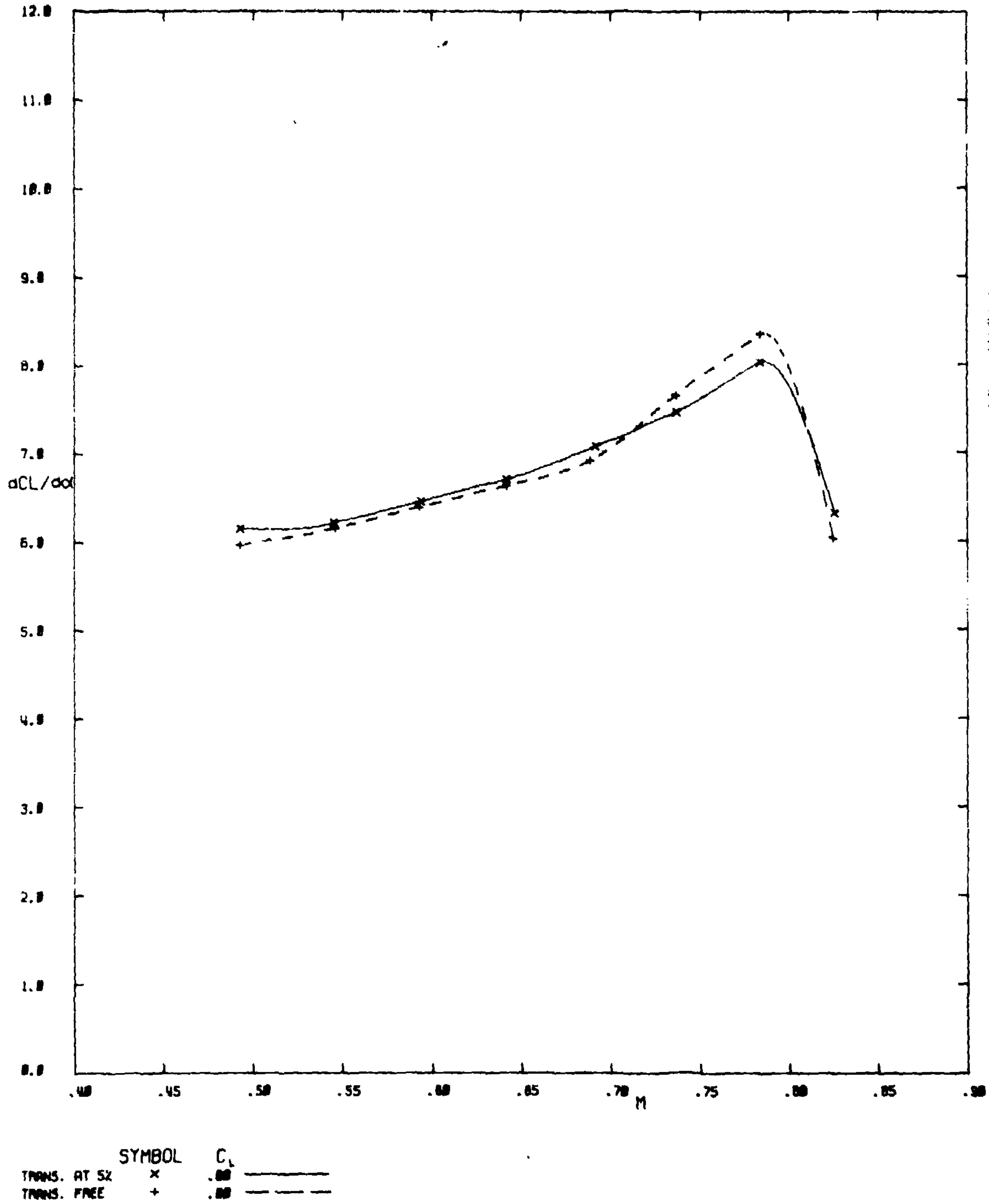


FIG. 7 VARIATION OF LIFT CURVE SLOPE WITH MACH NUMBER. COMPARISON BETWEEN TRANSITION FIXED AND NATURAL TRANSITION

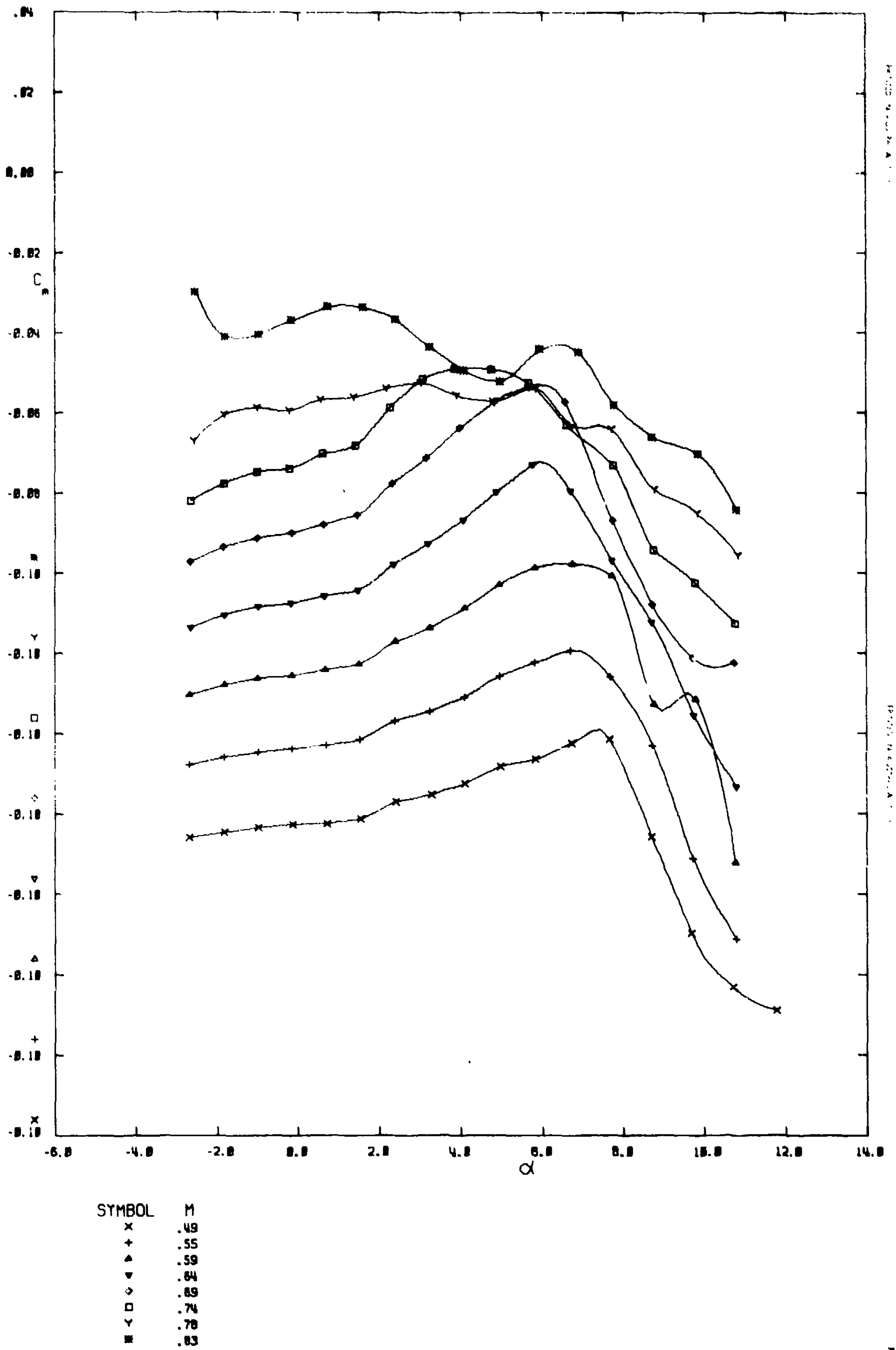


FIG. 8 VARIATION OF PITCHING MOMENT COEFFICIENT WITH INCIDENCE.NATURAL TRANSITION

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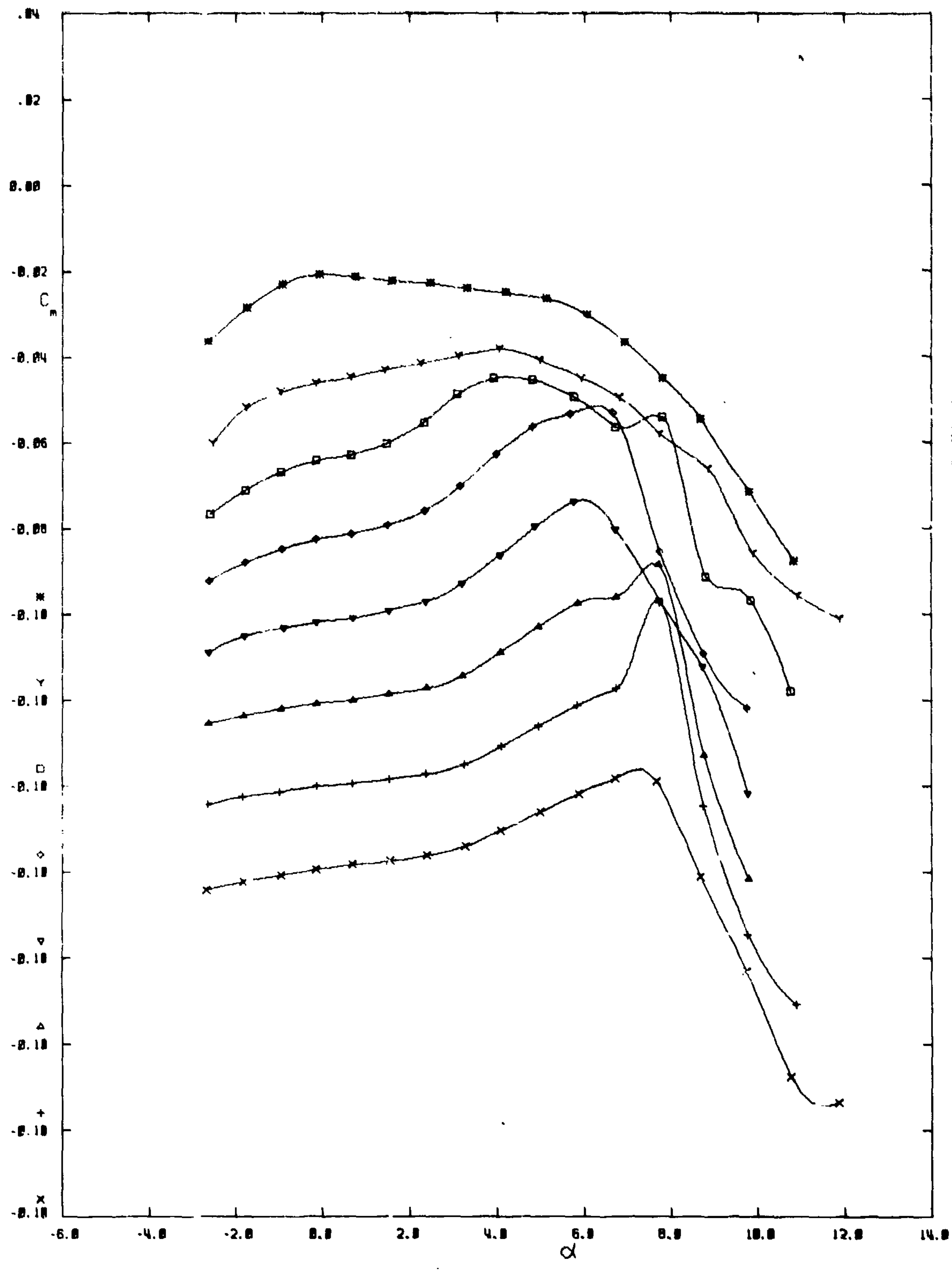

SYMBOL	M
×	.49
+	.54
▲	.59
▽	.64
◇	.69
□	.74
Y	.78
✱	.83

FIG. 9 VARIATION OF PITCHING MOMENT COEFFICIENT WITH INCIDENCE
TRANSITION FIXED AT 5% CHORD

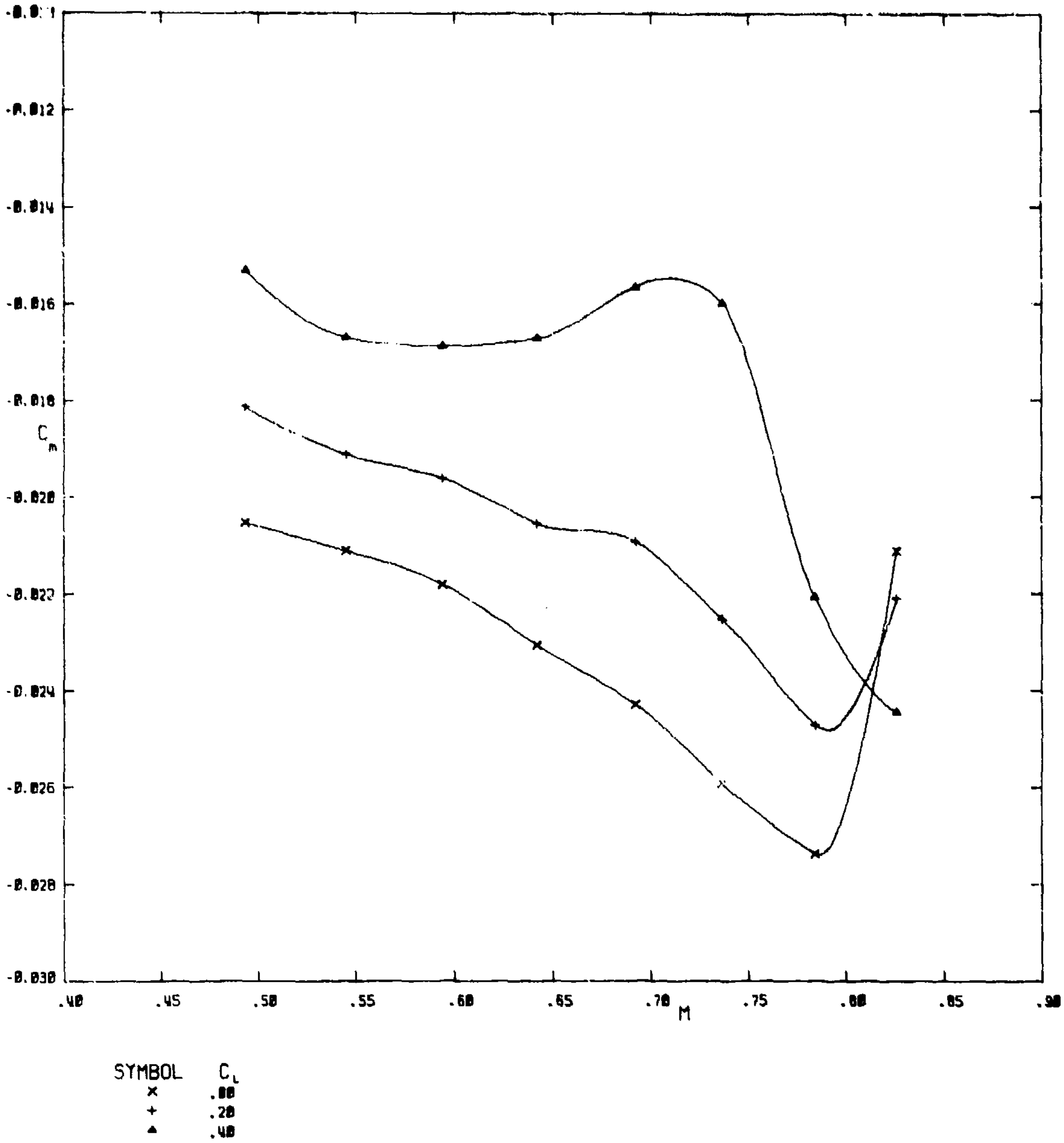

FIG. 10 VARIATION OF PITCHING MOMENT COEFFICIENT WITH MACH NUMBER. TRANSITION FIXED AT 5% CHORD

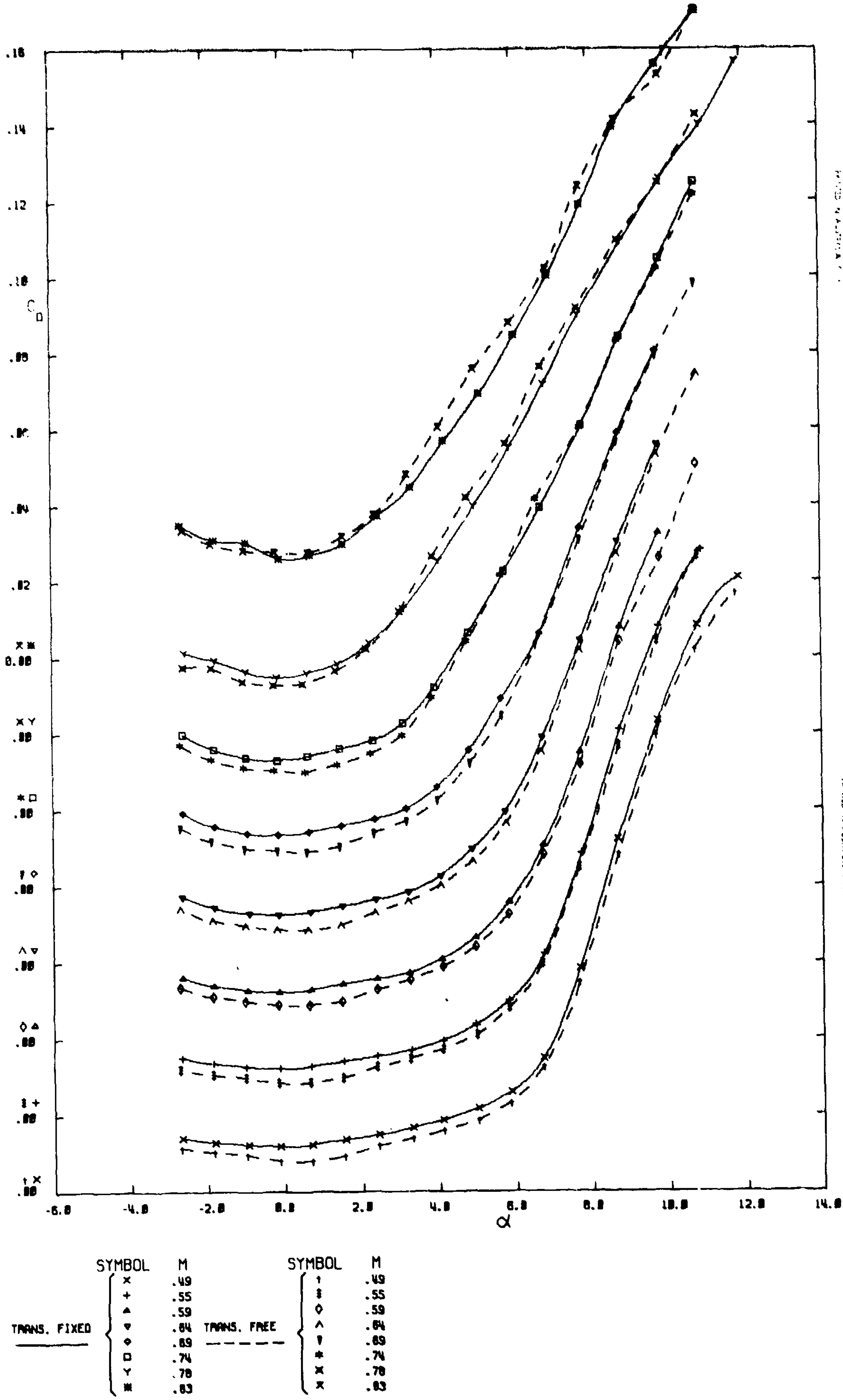

FIG. 11 VARIATION OF DRAG COEFFICIENT WITH INCIDENCE: COMPARISON BETWEEN TRANSITION FIXED AND NATURAL TRANSITION

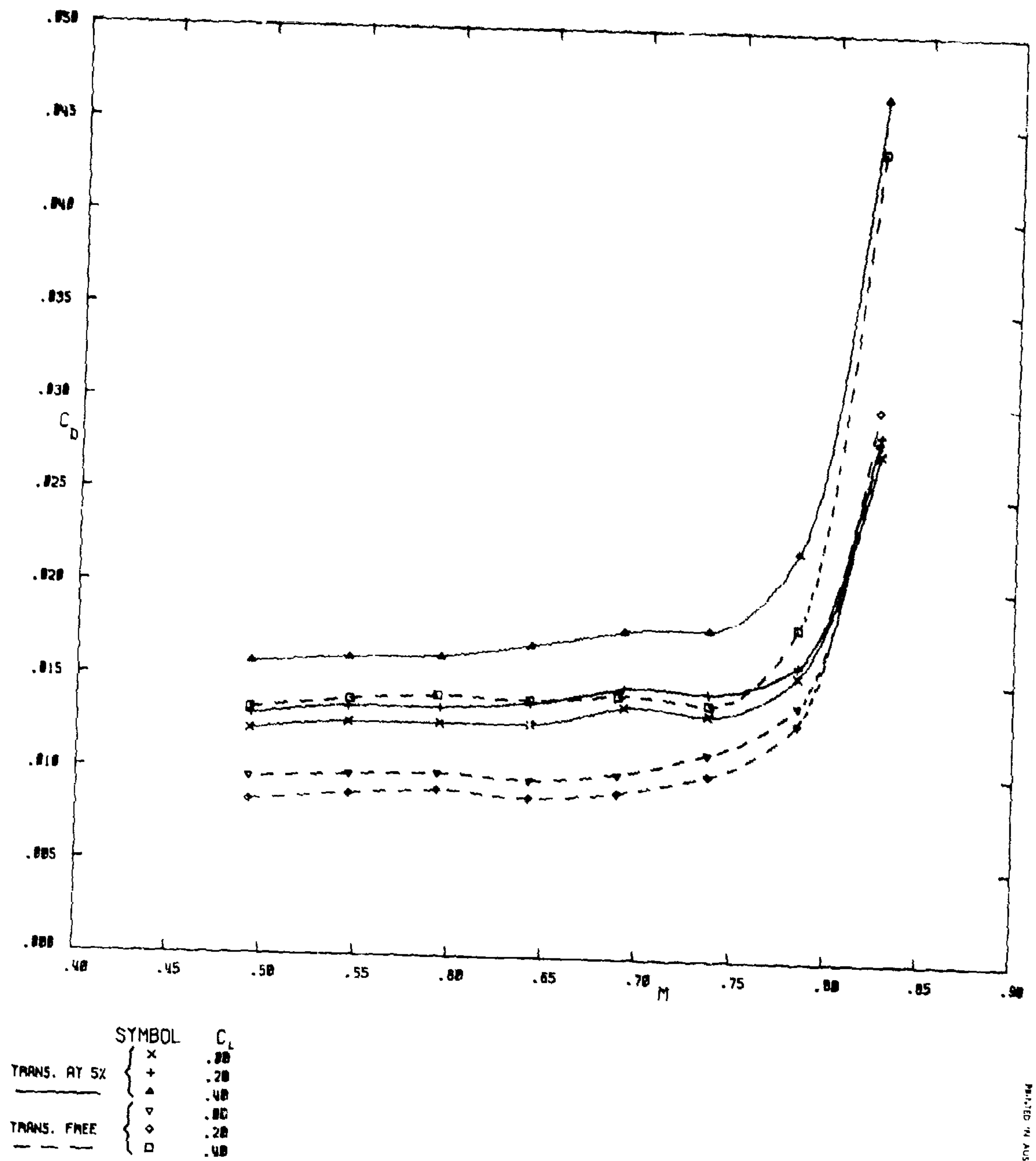

FIG. 12 VARIATION OF DRAG COEFFICIENT WITH MACH NUMBER: COMPARISON BETWEEN TRANSITION FIXED AND NATURAL TRANSITION

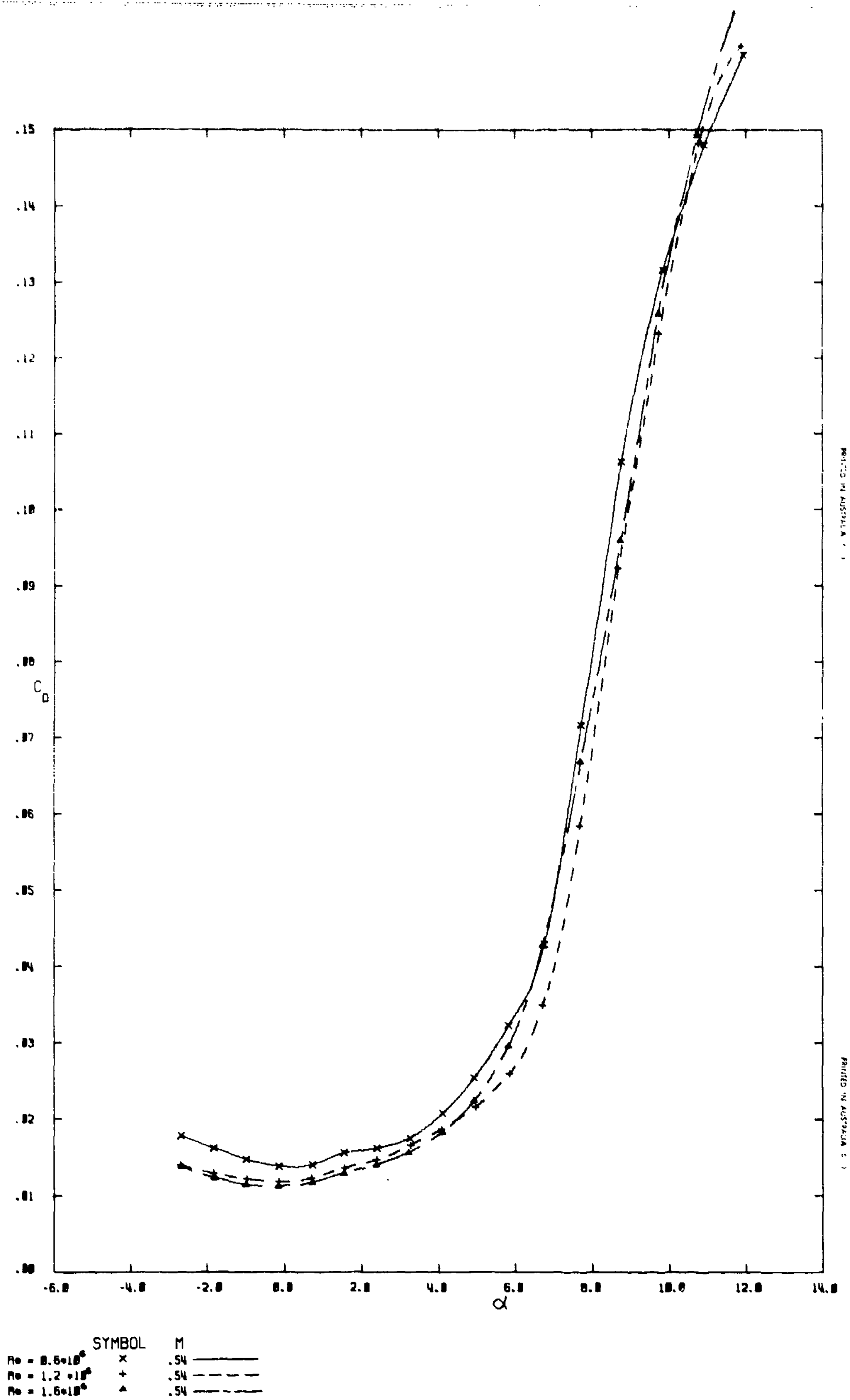

FIG. 13 EFFECT OF REYNOLDS NUMBER OF DRAG COEFFICIENT. TRANSITION FIXED AT 5% CHORD

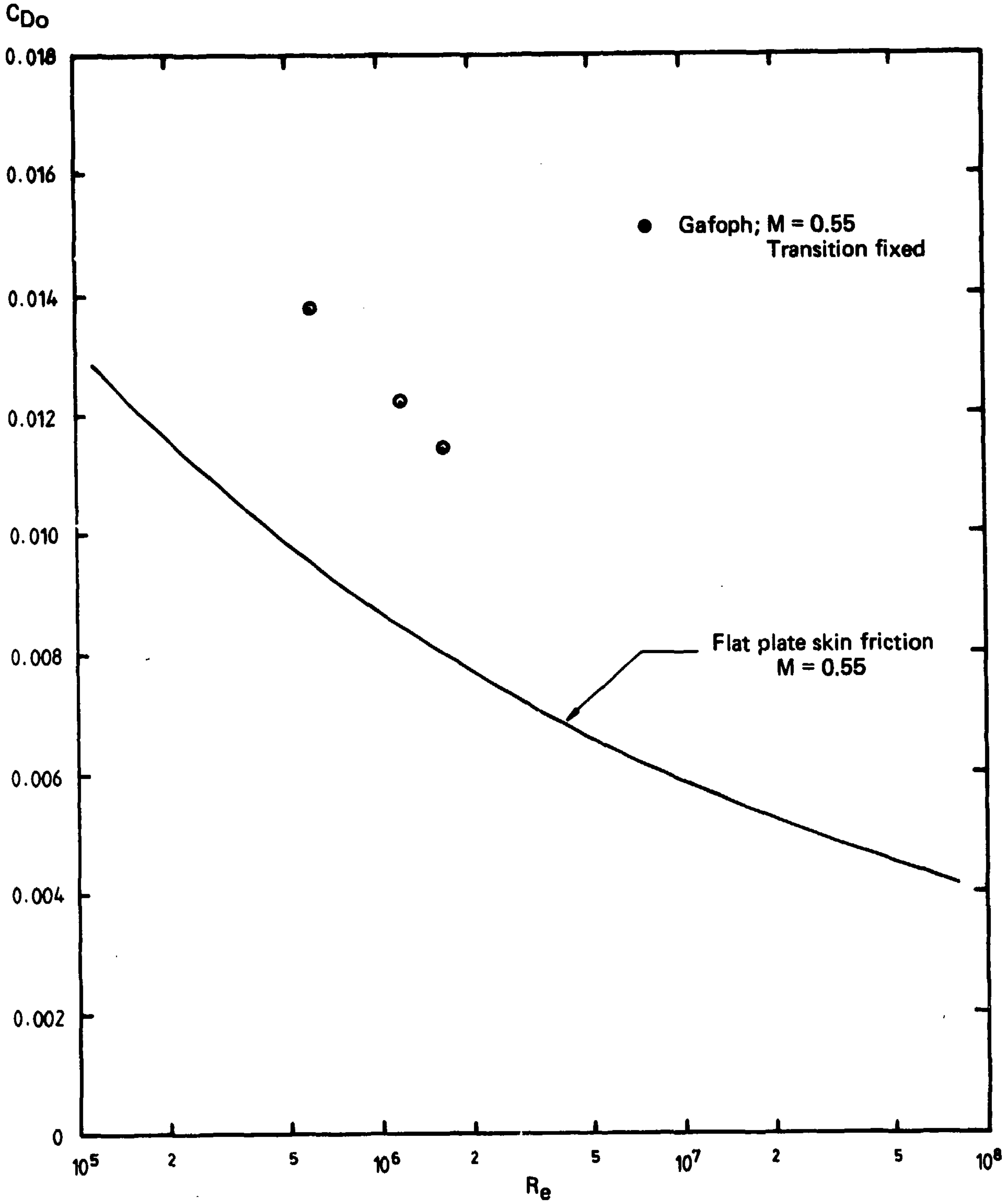

FIG. 14 VARIATION OF ZERO LIFT DRAG COEFFICIENT WITH REYNOLDS NUMBER. TRANSITION FIXED AT 5% CHORD

APPENDIX A

Tabulated Results

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
2	1.245	0.494	-2.68	-0.2052	-0.0244	0.0141	0.499	-3.04	-0.2026	-0.0233	0.0152
3	1.252	0.496	-1.83	-0.1149	-0.0224	0.0129	0.501	-2.03	-0.1135	-0.0213	0.0132
4	1.252	0.496	-0.96	-0.0211	-0.0209	0.0123	0.501	-1.00	-0.0208	-0.0198	0.0122
5	1.250	0.496	-0.15	0.0634	-0.0195	0.0119	0.501	-0.04	0.0626	-0.0184	0.0119
6	1.245	0.494	0.72	0.1575	-0.0186	0.0124	0.499	0.99	0.1555	-0.0175	0.0130
7	1.245	0.494	1.56	0.2525	-0.0178	0.0136	0.499	2.00	0.2493	-0.0167	0.0154
8	1.252	0.496	2.41	0.3462	-0.0164	0.0147	0.501	3.01	0.3419	-0.0153	0.0181
9	1.250	0.497	3.29	0.4406	-0.0143	0.0166	0.502	4.05	0.4351	-0.0132	0.0222
10	1.248	0.495	4.10	0.5205	-0.0106	0.0188	0.500	5.00	0.5140	-0.0096	0.0266
11	1.255	0.496	4.98	0.6033	-0.0064	0.0217	0.501	6.03	0.5957	-0.0054	0.0322
12	1.248	0.495	5.87	0.6857	-0.0019	0.0261	0.500	7.06	0.6771	-0.0010	0.0397
13	1.252	0.496	6.73	0.7515	0.0016	0.0350	0.501	8.04	0.7421	0.0025	0.0513
14	1.248	0.495	7.69	0.7818	0.0010	0.0584	0.500	9.05	0.7720	0.0019	0.0759
15	1.248	0.495	8.69	0.7647	-0.0212	0.0922	0.500	10.02	0.7551	-0.0201	0.1086
16	1.252	0.496	9.74	0.7455	-0.0431	0.1232	0.501	11.03	0.7362	-0.0418	0.1385
17	1.245	0.494	10.77	0.7183	-0.0675	0.1481	0.499	12.01	0.7093	-0.0660	0.1620
18	1.245	0.494	11.87	0.6377	-0.0736	0.1610	0.499	12.97	0.6297	-0.0720	0.1715
19	1.245	0.495	-0.13	0.0630	-0.0192	0.0122	0.500	-0.02	0.0622	-0.0181	0.0122

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
34	1.648	0.545	-2.66	-0.2164	-0.0249	0.0139	0.551	-3.04	-0.2135	-0.0237	0.0151
35	1.640	0.544	-1.80	-0.1183	-0.0230	0.0123	0.550	-2.01	-0.1167	-0.0218	0.0126
36	1.640	0.543	-1.01	-0.0276	-0.0217	0.0115	0.549	-1.06	-0.0272	-0.0205	0.0114
37	1.637	0.544	-0.16	0.0656	-0.0208	0.0113	0.550	-0.05	0.0647	-0.0196	0.0113
38	1.637	0.544	0.73	0.1651	-0.0199	0.0117	0.550	1.01	0.1629	-0.0187	0.0124
39	1.648	0.545	1.55	0.2607	-0.0188	0.0129	0.551	2.00	0.2572	-0.0176	0.0148
40	1.632	0.542	2.39	0.3587	-0.0171	0.0141	0.548	3.01	0.3539	-0.0159	0.0177
41	1.640	0.543	3.24	0.4522	-0.0143	0.0156	0.549	4.02	0.4461	-0.0132	0.0215
42	1.648	0.545	4.10	0.5419	-0.0099	0.0184	0.551	5.04	0.5346	-0.0088	0.0268
43	1.640	0.545	4.96	0.6292	-0.0046	0.0225	0.551	6.05	0.6207	-0.0036	0.0339
44	1.633	0.543	5.83	0.7085	0.0004	0.0296	0.549	7.06	0.6990	0.0014	0.0441
45	1.633	0.543	6.73	0.7724	0.0045	0.0428	0.549	8.07	0.7620	0.0055	0.0599
46	1.633	0.543	7.71	0.7814	-0.0008	0.0668	0.549	9.07	0.7709	0.0002	0.0841
47	1.637	0.543	8.75	0.7486	-0.0247	0.0959	0.549	10.03	0.7385	-0.0235	0.1114
48	1.630	0.542	9.73	0.7437	-0.0518	0.1257	0.548	11.01	0.7337	-0.0503	0.1408
49	1.635	0.542	10.74	0.7202	-0.0660	0.1493	0.548	11.98	0.7105	-0.0644	0.1631
50	1.632	0.542	11.79	0.6835	-0.0699	0.1668	0.548	12.97	0.6743	-0.0682	0.1789

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
148	1.202	0.545	-2.66	-0.2100	-0.0244	0.0151	0.551	-3.03	-0.2072	-0.0232	0.0163
149	1.207	0.545	-1.84	-0.1179	-0.0226	0.0135	0.551	-2.05	-0.1163	-0.0214	0.0138
150	1.199	0.543	-0.99	-0.0263	-0.0215	0.0127	0.549	-1.04	-0.0259	-0.0203	0.0126
151	1.202	0.545	-0.12	0.0660	-0.0203	0.0122	0.551	-0.01	0.0651	-0.0191	0.0122
152	1.201	0.545	0.72	0.1589	-0.0196	0.0129	0.551	0.99	0.1568	-0.0184	0.0135
153	1.202	0.544	1.55	0.2547	-0.0187	0.0141	0.550	1.99	0.2513	-0.0175	0.0159
154	1.204	0.544	2.40	0.3531	-0.0176	0.0154	0.550	3.01	0.3483	-0.0164	0.0189
155	1.207	0.544	3.26	0.4498	-0.0152	0.0169	0.550	4.04	0.4437	-0.0141	0.0227
156	1.207	0.543	4.10	0.5339	-0.0110	0.0195	0.549	5.03	0.5267	-0.0099	0.0277
157	1.207	0.544	4.95	0.6142	-0.0063	0.0235	0.550	6.02	0.6059	-0.0052	0.0344
158	1.202	0.543	5.83	0.6907	-0.0014	0.0301	0.549	7.03	0.6814	-0.0004	0.0438
159	1.207	0.544	6.74	0.7531	0.0025	0.0422	0.550	8.05	0.7430	0.0035	0.0585
160	1.202	0.544	7.75	0.7629	0.0226	0.0688	0.550	9.08	0.7526	0.0234	0.0852
161	1.202	0.543	8.75	0.7480	-0.0249	0.1008	0.549	10.05	0.7379	-0.0237	0.1163
162	1.202	0.543	9.78	0.7148	-0.0545	0.1279	0.549	11.01	0.7052	-0.0530	0.1417
163	1.204	0.545	10.87	0.6496	-0.0708	0.1483	0.551	11.99	0.6408	-0.0691	0.1593
164	1.202	0.544	-0.12	0.0639	-0.0200	0.0116	0.550	-0.01	0.0630	-0.0188	0.0116

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
54	0.604	0.545	-2.68	-0.2080	-0.0250	0.0179	0.551	-3.04	-0.2052	-0.0238	0.0190
55	0.604	0.545	-1.83	-0.1097	-0.0232	0.0162	0.551	-2.02	-0.1082	-0.0220	0.0164
56	0.601	0.544	-0.99	-0.0237	-0.0217	0.0147	0.550	-1.03	-0.0234	-0.0205	0.0146
57	0.601	0.544	-0.13	0.0616	-0.0201	0.0138	0.550	-0.03	0.0608	-0.0189	0.0138
58	0.604	0.545	0.72	0.1560	-0.0196	0.0140	0.551	0.99	0.1539	-0.0184	0.0146
59	0.604	0.545	1.56	0.2503	-0.0185	0.0156	0.551	1.99	0.2469	-0.0173	0.0173
60	0.604	0.545	2.40	0.3456	-0.0177	0.0162	0.551	3.00	0.3409	-0.0165	0.0196
61	0.604	0.545	3.26	0.4385	-0.0156	0.0175	0.551	4.02	0.4326	-0.0144	0.0230
62	0.604	0.544	4.11	0.5243	-0.0120	0.0208	0.550	5.02	0.5172	-0.0109	0.0287
63	0.604	0.544	4.96	0.6010	-0.0070	0.0254	0.550	6.00	0.5929	-0.0059	0.0358
64	0.604	0.544	5.83	0.6843	-0.0034	0.0324	0.550	7.02	0.6751	-0.0024	0.0458
65	0.603	0.543	6.76	0.7311	0.0017	0.0429	0.549	8.03	0.7213	0.0027	0.0582
66	0.603	0.543	7.72	0.7439	-0.0129	0.0716	0.549	9.01	0.7339	-0.0118	0.0872
67	0.607	0.544	8.77	0.7118	-0.0432	0.1062	0.550	10.00	0.7022	-0.0418	0.1201
68	0.604	0.545	9.84	0.6642	-0.0635	0.1316	0.551	10.99	0.6552	-0.0619	0.1433
69	0.607	0.544	10.93	0.6112	-0.0726	0.1480	0.550	11.98	0.6030	-0.0709	0.1576
70	0.607	0.545	11.96	0.5897	-0.0740	0.1598	0.551	12.97	0.5817	-0.0723	0.1685

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
128	1.211	0.594	-2.63	-0.2157	-0.0257	0.0160	0.601	-3.01	-0.2125	-0.0243	0.0172
129	1.206	0.594	-1.82	-0.1209	-0.0238	0.0138	0.601	-2.03	-0.1191	-0.0225	0.0141
130	1.206	0.594	-0.96	-0.0247	-0.0222	0.0127	0.601	-1.01	-0.0243	-0.0209	0.0126
131	1.202	0.592	-0.15	0.0641	-0.0209	0.0122	0.599	-0.04	0.0632	-0.0196	0.0122
132	1.202	0.592	0.71	0.1628	-0.0202	0.0129	0.599	0.99	0.1604	-0.0189	0.0135
133	1.206	0.594	1.53	0.2607	-0.0189	0.0144	0.601	1.98	0.2569	-0.0176	0.0162
134	1.206	0.594	2.38	0.3639	-0.0176	0.0157	0.601	3.01	0.3585	-0.0163	0.0194
135	1.206	0.593	3.22	0.4596	-0.0146	0.0173	0.600	4.02	0.4528	-0.0134	0.0233
136	1.206	0.593	4.08	0.5432	-0.0092	0.0208	0.600	5.02	0.5352	-0.0080	0.0292
137	1.201	0.591	4.94	0.6277	-0.0031	0.0263	0.598	6.03	0.6185	-0.0020	0.0376
138	1.209	0.594	5.85	0.7102	0.0024	0.0358	0.601	7.08	0.6997	0.0035	0.0502
139	1.209	0.595	6.75	0.7575	0.0037	0.0505	0.602	8.06	0.7463	0.0048	0.0668
140	1.209	0.593	7.74	0.7508	0.0113	0.0751	0.600	9.04	0.7397	0.0123	0.0908
143	1.209	0.594	8.77	0.7329	-0.0330	0.1076	0.601	10.04	0.7221	-0.0316	0.1222
144	1.209	0.593	9.78	0.7015	-0.0616	0.1326	0.600	10.99	0.6912	-0.0599	0.1456
145	1.201	0.591	-0.13	0.0660	-0.0211	0.0119	0.598	-0.02	0.0650	-0.0198	0.0119

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
91	1.219	0.643	-2.64	-0.2226	-0.0292	0.0173	0.651	-3.03	-0.2189	-0.0276	0.0185
92	1.206	0.641	-1.81	-0.1252	-0.0252	0.0143	0.649	-2.03	-0.1232	-0.0237	0.0146
93	1.215	0.646	-0.92	-0.0220	-0.0235	0.0129	0.654	-0.96	-0.0216	-0.0220	0.0128
94	1.209	0.642	-0.92	-0.0216	-0.0235	0.0128	0.650	-0.96	-0.0212	-0.0220	0.0127
95	1.211	0.643	-0.13	0.0655	-0.0220	0.0124	0.651	-0.02	0.0644	-0.0205	0.0124
96	1.206	0.641	0.72	0.1695	-0.0212	0.0132	0.649	1.01	0.1667	-0.0197	0.0139
97	1.206	0.642	1.53	0.2701	-0.0193	0.0147	0.650	2.00	0.2657	-0.0179	0.0167
98	1.206	0.641	2.36	0.3741	-0.0174	0.0163	0.649	3.01	0.3680	-0.0160	0.0202
99	1.206	0.641	3.19	0.4722	-0.0132	0.0183	0.649	4.01	0.4645	-0.0118	0.0246
100	1.212	0.642	4.05	0.5704	-0.0067	0.0227	0.650	5.04	0.5610	-0.0054	0.0319
101	1.211	0.643	4.88	0.6714	0.0002	0.0297	0.651	6.04	0.6604	0.0014	0.0425
102	1.211	0.643	5.74	0.7546	0.0061	0.0394	0.651	7.05	0.7422	0.0072	0.0556
103	1.214	0.644	6.73	0.7662	-0.0003	0.0587	0.652	8.06	0.7536	0.0009	0.0752
104	1.209	0.642	7.75	0.7520	-0.0169	0.0844	0.650	9.05	0.7397	-0.0155	0.0999
105	1.209	0.641	8.73	0.7402	-0.0326	0.1103	0.649	10.01	0.7281	-0.0310	0.1250
106	1.209	0.642	9.77	0.7132	-0.0618	0.1357	0.650	11.00	0.7015	-0.0599	0.1490
107	1.209	0.642	-0.14	0.0608	-0.0226	0.0120	0.650	-0.04	0.0598	-0.0211	0.0120

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
72	1.184	0.692	-2.61	-0.2331	-0.0323	0.0192	0.702	-3.02	-0.2287	-0.0305	0.0205
73	1.183	0.690	-1.78	-0.1337	-0.0281	0.0156	0.700	-2.02	-0.1312	-0.0264	0.0159
74	1.184	0.691	-0.94	-0.0266	-0.0250	0.0138	0.701	-0.99	-0.0261	-0.0233	0.0136
75	1.183	0.690	-0.14	0.0685	-0.0228	0.0133	0.700	-0.02	0.0672	-0.0211	0.0133
76	1.181	0.689	0.69	0.1727	-0.0215	0.0141	0.699	0.99	0.1695	-0.0198	0.0148
77	1.184	0.691	1.51	0.2777	-0.0194	0.0159	0.701	1.99	0.2725	-0.0178	0.0179
78	1.184	0.691	2.34	0.3876	-0.0163	0.0175	0.701	3.01	0.3803	-0.0147	0.0216
79	1.183	0.689	3.17	0.4947	-0.0103	0.0203	0.699	4.03	0.4855	-0.0088	0.0271
80	1.183	0.689	3.98	0.6061	-0.0030	0.0259	0.699	5.03	0.5948	-0.0016	0.0362
81	1.183	0.689	4.81	0.7131	0.0036	0.0354	0.699	6.05	0.6998	0.0049	0.0497
82	1.183	0.689	5.67	0.8069	0.0064	0.0489	0.699	7.07	0.7918	0.0077	0.0672
83	1.183	0.690	6.66	0.8077	0.0067	0.0660	0.700	8.06	0.7926	0.0080	0.0841
84	1.196	0.693	7.76	0.7311	-0.0256	0.0938	0.703	9.02	0.7173	-0.0239	0.1081
85	1.188	0.691	8.76	0.7385	-0.0494	0.1185	0.701	10.03	0.7246	-0.0474	0.1328
86	1.183	0.689	9.74	0.7376	-0.0621	0.1404	0.699	11.01	0.7238	-0.0599	0.1543
87	1.186	0.689	-0.15	0.0642	-0.0231	0.0128	0.699	-0.04	0.0630	-0.0214	0.0127

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
52	1.142	0.738	-2.60	-0.2554	-0.0369	0.0198	0.750	-3.05	-0.2497	-0.0347	0.0214
53	1.138	0.738	-1.77	-0.1396	-0.0312	0.0159	0.750	-2.02	-0.1365	-0.0291	0.0162
54	1.140	0.738	-0.97	-0.0370	-0.0271	0.0137	0.750	-1.04	-0.0362	-0.0251	0.0135
55	1.142	0.739	-0.14	0.0672	-0.0244	0.0130	0.751	-0.03	0.0657	-0.0224	0.0129
56	1.142	0.739	0.67	0.1798	-0.0230	0.0141	0.751	0.98	0.1758	-0.0210	0.0148
57	1.138	0.738	1.50	0.2910	-0.0204	0.0159	0.750	2.00	0.2846	-0.0185	0.0181
58	1.145	0.739	2.32	0.4086	-0.0157	0.0180	0.751	3.02	0.3995	-0.0138	0.0225
59	1.148	0.738	3.10	0.5367	-0.0089	0.0226	0.750	4.03	0.5248	-0.0072	0.0306
60	1.143	0.738	3.93	0.6485	-0.0053	0.0322	0.750	5.05	0.6341	-0.0036	0.0438
61	1.143	0.738	4.81	0.7131	-0.0056	0.0462	0.750	6.04	0.6973	-0.0039	0.0601
62	1.142	0.738	5.77	0.7344	-0.0097	0.0624	0.750	7.04	0.7181	-0.0079	0.0770
63	1.145	0.738	6.72	0.7638	-0.0167	0.0792	0.750	8.04	0.7469	-0.0148	0.0948
64	1.145	0.739	7.81	0.7126	-0.0142	0.1008	0.751	9.04	0.6967	-0.0124	0.1138
65	1.145	0.738	8.82	0.6890	-0.0515	0.1241	0.750	10.00	0.6737	-0.0491	0.1358
66	1.145	0.738	9.84	0.6738	-0.0569	0.1447	0.750	11.00	0.6589	-0.0544	0.1555
67	1.140	0.736	10.77	0.6933	-0.0781	0.1649	0.748	11.96	0.6781	-0.0753	0.1762
68	1.142	0.738	-0.14	0.0671	-0.0247	0.0126	0.750	-0.03	0.0656	-0.0227	0.0125

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
32	1.130	0.784	-2.53	-0.3022	-0.0402	0.0212	0.801	-3.06	-0.2938	-0.0374	0.0234
33	1.127	0.783	-1.77	-0.1553	-0.0320	0.0193	0.800	-2.04	-0.1510	-0.0294	0.0196
34	1.127	0.783	-0.95	-0.0413	-0.0283	0.0163	0.800	-1.03	-0.0402	-0.0258	0.0160
35	1.127	0.784	-0.14	0.0672	-0.0263	0.0146	0.801	-0.03	0.0653	-0.0238	0.0144
36	1.127	0.783	0.67	0.1866	-0.0249	0.0157	0.800	0.99	0.1815	-0.0225	0.0164
37	1.130	0.783	1.46	0.3097	-0.0232	0.0182	0.800	1.99	0.3012	-0.0208	0.0206
38	1.130	0.784	2.27	0.4293	-0.0218	0.0236	0.801	3.01	0.4174	-0.0194	0.0284
39	1.127	0.782	3.14	0.5123	-0.0200	0.0326	0.799	4.02	0.4982	-0.0177	0.0394
40	1.130	0.783	4.07	0.5605	-0.0184	0.0451	0.800	5.03	0.5450	-0.0161	0.0532
41	1.130	0.783	4.99	0.6039	-0.0211	0.0596	0.800	6.03	0.5872	-0.0187	0.0688
42	1.130	0.782	5.94	0.6428	-0.0251	0.0750	0.799	7.04	0.6252	-0.0227	0.0853
43	1.132	0.785	6.84	0.6832	-0.0298	0.0917	0.802	8.01	0.6642	-0.0272	0.1032
44	1.130	0.782	7.76	0.7365	-0.0382	0.1100	0.799	9.02	0.7163	-0.0355	0.1233
45	1.130	0.784	8.87	0.6714	-0.0465	0.1289	0.801	10.02	0.6528	-0.0436	0.1392
46	1.135	0.784	9.90	0.6288	-0.0660	0.1458	0.801	10.97	0.6114	-0.0627	0.1541
47	1.130	0.783	10.94	0.6011	-0.0759	0.1600	0.800	11.96	0.5845	-0.0724	0.1671
48	1.130	0.782	11.90	0.6234	-0.0810	0.1767	0.799	12.96	0.6063	-0.0775	0.1843
49	1.129	0.785	-0.14	0.0662	-0.0268	0.0139	0.802	-0.03	0.0644	-0.0243	0.0137

GAFOPH AEROFOIL

TRANSITION FIXED AT 5% CHORD

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
14	1.143	0.827	-2.63	-0.2472	-0.0366	0.0349	0.852	-3.06	-0.2379	-0.0330	0.0356
15	1.140	0.826	-1.73	-0.1476	-0.0286	0.0308	0.851	-1.99	-0.1421	-0.0253	0.0306
16	1.142	0.828	-0.92	-0.0536	-0.0232	0.0303	0.853	-1.02	-0.0516	-0.0200	0.0295
17	1.140	0.826	-0.07	0.0366	-0.0207	0.0259	0.851	-0.01	0.0352	-0.0176	0.0252
18	1.143	0.826	0.77	0.1291	-0.0214	0.0268	0.851	0.99	0.1243	-0.0183	0.0265
19	1.142	0.825	1.62	0.2199	-0.0223	0.0299	0.849	1.99	0.2118	-0.0192	0.0304
20	1.142	0.827	2.50	0.3011	-0.0231	0.0371	0.852	3.01	0.2897	-0.0199	0.0386
21	1.142	0.825	3.34	0.3860	-0.0243	0.0448	0.849	4.00	0.3717	-0.0211	0.0477
22	1.140	0.826	4.24	0.4484	-0.0253	0.0569	0.851	5.00	0.4316	-0.0221	0.0609
23	1.142	0.824	5.14	0.5144	-0.0266	0.0693	0.848	6.02	0.4955	-0.0234	0.0748
24	1.147	0.825	6.07	0.5637	-0.0305	0.0846	0.850	7.03	0.5427	-0.0271	0.0912
25	1.143	0.826	6.96	0.6190	-0.0368	0.1005	0.851	8.01	0.5958	-0.0332	0.1084
26	1.143	0.825	7.83	0.6880	-0.0452	0.1189	0.850	9.00	0.6624	-0.0414	0.1289
27	1.147	0.826	8.70	0.7623	-0.0549	0.1395	0.851	9.99	0.7337	-0.0508	0.1519
28	1.147	0.826	9.80	0.7067	-0.0718	0.1562	0.851	11.00	0.6802	-0.0673	0.1658
29	1.145	0.825	10.84	0.6632	-0.0877	0.1699	0.849	11.96	0.6387	-0.0828	0.1776

GAFOPH AEROFOIL

TRANSITION FREE

SER	REYN	CORRECTED MACH	CORRECTED INCID	CORRECTED LIFT	CORRECTED PITCH	CORRECTED DRAG	UNCORRECTED MACH	UNCORRECTED INCID	UNCORRECTED LIFT	UNCORRECTED PITCH	UNCORRECTED DRAG
138	1.230	0.494	-2.71	-0.1833	-0.0262	0.0114	0.499	-3.03	-0.1810	-0.0250	0.0123
139	1.227	0.495	-1.86	-0.0913	-0.0249	0.0103	0.500	-2.02	-0.0902	-0.0237	0.0105
140	1.224	0.495	-1.01	-0.0008	-0.0237	0.0096	0.500	-1.01	-0.0008	-0.0226	0.0095
141	1.224	0.495	-0.15	0.0814	-0.0228	0.0080	0.500	-0.01	0.0804	-0.0217	0.0081
142	1.229	0.496	0.70	0.1735	-0.0225	0.0081	0.501	1.00	0.1713	-0.0214	0.0089
143	1.224	0.495	1.54	0.2655	-0.0213	0.0093	0.500	2.00	0.2622	-0.0202	0.0113
144	1.227	0.495	2.41	0.3404	-0.0174	0.0120	0.500	3.00	0.3361	-0.0163	0.0153
145	1.227	0.495	3.29	0.4304	-0.0154	0.0140	0.500	4.04	0.4250	-0.0143	0.0193
146	1.227	0.495	4.12	0.5137	-0.0125	0.0160	0.500	5.01	0.5073	-0.0115	0.0236
147	1.224	0.494	4.99	0.5959	-0.0085	0.0187	0.499	6.02	0.5885	-0.0075	0.0290
148	1.224	0.494	5.86	0.6811	-0.0066	0.0234	0.499	7.04	0.6726	-0.0056	0.0368
149	1.227	0.495	6.72	0.7533	-0.0027	0.0328	0.500	8.03	0.7439	-0.0017	0.0492
150	1.224	0.494	7.67	0.7873	-0.0016	0.0547	0.499	9.04	0.7775	-0.0007	0.0725
151	1.227	0.495	8.70	0.7726	-0.0258	0.0882	0.500	10.04	0.7629	-0.0246	0.1050
152	1.224	0.494	9.68	0.7735	-0.0498	0.1194	0.499	11.02	0.7638	-0.0484	0.1360
153	1.227	0.495	10.72	0.7436	-0.0634	0.1419	0.500	12.00	0.7343	-0.0619	0.1569
154	1.227	0.495	11.78	0.6995	-0.0689	0.1570	0.500	12.99	0.6907	-0.0674	0.1700

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
118	1.219	0.546	-2.70	-0.1880	-0.0279	0.0121	0.552	-3.03	-0.1855	-G.0266	0.0130
119	1.220	0.545	-1.85	-0.0942	-0.0261	0.0106	0.551	-2.02	-0.0929	-0.0248	0.0108
121	1.211	0.543	-1.01	-0.0008	-0.0248	0.0098	0.549	-1.01	-0.0008	-0.0236	0.0097
122	1.217	0.545	-0.15	0.0844	-0.0238	0.0084	0.551	-0.01	0.0833	-0.0226	0.0085
123	1.217	0.545	0.69	0.1765	-0.0230	0.0086	0.551	0.99	0.1741	-0.0218	0.0094
124	1.211	0.543	1.52	0.2707	-0.0216	0.0097	0.549	1.99	0.2671	-0.0204	0.0118
125	1.211	0.543	2.40	0.3484	-0.0170	0.0126	0.549	3.00	0.3437	-0.0158	0.0160
126	1.220	0.544	3.26	0.4397	-0.0145	0.0148	0.550	4.02	0.4338	-0.0134	0.0203
127	1.214	0.543	4.12	0.5263	-0.0110	0.0173	0.549	5.03	0.5192	-0.0099	0.0253
128	1.332	0.542	4.97	0.6064	-0.0058	0.0211	0.548	6.02	0.5983	-0.0047	0.0317
129	1.214	0.543	5.84	0.6916	-0.0024	0.0282	0.549	7.04	0.6823	-0.0014	0.0420
130	1.211	0.542	6.71	0.7548	0.0007	0.0397	0.548	8.02	0.7447	0.0017	0.0561
131	1.217	0.545	7.68	0.7762	-0.0062	0.0650	0.551	9.03	0.7657	-0.0051	0.0821
132	1.217	0.544	8.73	0.7480	-0.0232	0.0967	0.550	10.03	0.7379	-0.0220	0.1122
133	1.214	0.543	9.73	0.7423	-0.0513	0.1243	0.549	11.01	0.7323	-0.0498	0.1393
134	1.214	0.543	10.79	0.7202	-0.0712	0.1467	0.549	12.03	0.7105	-0.0695	0.1605

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
98	1.215	0.593	-2.70	-0.1940	-0.0304	0.0133	0.600	-3.04	-0.1911	-0.0290	0.0143
99	1.212	0.592	-1.84	-0.0948	-0.0282	0.0110	0.599	-2.01	-0.0934	-0.0268	0.0111
100	1.212	0.593	-1.02	-0.0010	-0.0265	0.0098	0.600	-1.02	-0.0010	-0.0251	0.0097
101	1.214	0.594	-0.17	0.0875	-0.0257	0.0088	0.601	-0.02	0.0862	-0.0243	0.0089
102	1.214	0.594	0.67	0.1814	-0.0243	0.0088	0.601	0.98	0.1787	-0.0239	0.0097
103	1.212	0.593	1.50	0.2819	-0.0228	0.0100	0.600	1.99	0.2777	-0.0215	0.0122
104	1.215	0.593	2.39	0.3580	-0.0174	0.0129	0.600	3.01	0.3527	-0.0161	0.0165
105	1.214	0.594	3.24	0.4501	-0.0138	0.0154	0.601	4.02	0.4435	-0.0126	0.0212
106	1.217	0.594	4.11	0.5402	-0.0090	0.0188	0.601	5.05	0.5322	-0.0078	0.0272
107	1.215	0.592	4.95	0.6262	-0.0030	0.0241	0.599	6.04	0.6170	-0.0019	0.0353
108	1.215	0.593	5.83	0.7056	0.0013	0.0327	0.600	7.05	0.6952	0.0024	0.0469
110	1.220	0.595	6.74	0.7599	0.0022	0.0482	0.602	8.06	0.7487	0.0033	0.0646
111	1.212	0.592	7.72	0.7594	-0.0009	0.0718	0.599	9.04	0.7482	0.0002	0.0879
112	1.212	0.592	8.77	0.7363	-0.0329	0.1040	0.599	10.04	0.7255	-0.0315	0.1188
113	1.212	0.592	9.81	0.6926	-0.0316	0.1261	0.599	11.01	0.6824	-0.0302	0.1388
114	1.215	0.592	10.78	0.6911	-0.0722	0.1506	0.599	11.97	0.6809	-0.0704	0.1630

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	IACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
79	1.214	0.643	-2.69	-0.1947	-0.0337	0.0141	0.651	-3.03	-0.1915	-0.0321	0.0150
80	1.219	0.643	-1.85	-0.0981	-0.0306	0.0109	0.651	-2.02	-0.0965	-0.0290	0.0111
81	1.212	0.640	-1.01	0.0012	-0.0284	0.0095	0.648	-1.01	0.0012	-0.0269	0.0094
82	1.217	0.643	-0.18	0.0951	-0.0276	0.0085	0.651	-0.02	0.0935	-0.0261	0.0087
83	1.214	0.642	0.65	0.1896	-0.0258	0.0085	0.650	0.98	0.1865	-0.0243	0.0095
84	1.212	0.641	1.48	0.2937	-0.0245	0.0098	0.649	1.99	0.2889	-0.0230	0.0122
85	1.225	0.644	2.35	0.3753	-0.0180	0.0130	0.652	3.00	0.3691	-0.0166	0.0170
86	1.214	0.642	3.20	0.4672	-0.0129	0.0159	0.650	4.01	0.4595	-0.0115	0.0221
87	1.217	0.643	4.05	0.5649	-0.0069	0.0201	0.651	5.03	0.5556	-0.0056	0.0292
88	1.217	0.643	4.90	0.6579	0.0002	0.0266	0.651	6.04	0.6471	0.0014	0.0389
89	1.217	0.642	5.77	0.7452	0.0072	0.0365	0.650	7.06	0.7330	0.0083	0.0523
90	1.217	0.642	6.71	0.7705	0.0004	0.0550	0.650	8.05	0.7579	0.0016	0.0717
91	1.217	0.643	7.73	0.7592	-0.0169	0.0815	0.651	9.04	0.7467	-0.0155	0.0974
92	1.217	0.642	8.72	0.7489	-0.0324	0.1069	0.650	10.01	0.7366	-0.0308	0.1220
93	1.217	0.643	9.76	0.7213	-0.0557	0.1330	0.651	11.00	0.7094	-0.0538	0.1466
94	1.217	0.641	10.79	0.6995	-0.0734	0.1543	0.649	11.99	0.6881	-0.0713	0.1668

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
60	1.181	0.689	-2.68	-0.2029	-0.0373	0.0154	0.699	-3.04	-0.1991	-0.0354	0.0164
61	1.183	0.691	-1.86	-0.1012	-0.0337	0.0118	0.701	-2.04	-0.0993	-0.0319	0.0119
62	1.183	0.690	-1.03	0.0019	-0.0314	0.0099	0.700	-1.03	0.0019	-0.0296	0.0098
63	1.183	0.690	-0.17	0.1049	-0.0301	0.0091	0.700	0.01	0.1029	-0.0283	0.0093
64	1.183	0.690	0.64	0.1993	-0.0279	0.0090	0.700	0.98	0.1956	-0.0262	0.0100
65	1.181	0.689	1.46	0.3067	-0.0256	0.0104	0.699	1.99	0.3010	-0.0239	0.0130
66	1.184	0.691	2.33	0.3903	-0.0178	0.0139	0.701	3.00	0.3830	-0.0162	0.0181
67	1.183	0.690	3.17	0.4980	-0.0113	0.0170	0.700	4.03	0.4887	-0.0098	0.0240
68	1.181	0.688	4.00	0.6035	-0.0039	0.0224	0.698	5.04	0.5923	-0.0025	0.0327
69	1.186	0.690	4.82	0.7086	0.0027	0.0320	0.700	6.05	0.6953	0.0040	0.0462
70	1.186	0.690	5.70	0.7852	0.0064	0.0448	0.700	7.06	0.7705	0.0077	0.0621
71	1.183	0.689	6.58	0.8554	0.0026	0.0631	0.699	8.06	0.8394	0.0039	0.0835
72	1.186	0.690	7.75	0.7376	-0.0270	0.0908	0.700	9.02	0.7238	-0.0253	0.1054
73	1.183	0.689	8.73	0.7494	-0.0479	0.1164	0.699	10.02	0.7354	-0.0459	0.1312
74	1.186	0.690	9.73	0.7446	-0.0615	0.1392	0.700	11.01	0.7306	-0.0593	0.1534
75	1.186	0.690	10.76	0.7174	-0.0625	0.1583	0.700	11.99	0.7040	-0.0603	0.1711

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
40	1.168	0.738	-2.65	-0.2196	-0.0421	0.0170	0.750	-3.04	-0.2147	-0.0398	0.0181
41	1.163	0.736	-1.85	-0.1049	-0.0378	0.0132	0.748	-2.04	-0.1026	-0.0356	0.0133
42	1.168	0.739	-1.01	0.0049	-0.0349	0.0111	0.751	-1.01	0.0048	-0.0327	0.0109
43	1.168	0.739	-0.21	0.1144	-0.0340	0.0103	0.751	-0.02	0.1119	-0.0319	0.0105
44	1.168	0.738	0.62	0.2115	-0.0304	0.0100	0.750	0.98	0.2068	-0.0283	0.0111
45	1.168	0.738	1.42	0.3293	-0.0283	0.0119	0.750	1.99	0.3220	-0.0263	0.0148
46	1.165	0.738	2.27	0.4295	-0.0189	0.0146	0.750	3.01	0.4200	-0.0170	0.0197
47	1.171	0.738	3.08	0.5534	-0.0118	0.0195	0.750	4.03	0.5411	-0.0100	0.0280
48	1.171	0.738	3.88	0.6677	-0.0091	0.0293	0.750	5.03	0.6529	-0.0074	0.0417
49	1.170	0.739	4.77	0.7406	-0.0091	0.0440	0.751	6.05	0.7244	-0.0074	0.0591
50	1.168	0.737	5.69	0.7864	-0.0128	0.0613	0.749	7.05	0.7690	-0.0110	0.0782
52	1.170	0.740	6.62	0.8178	-0.0233	0.0814	0.752	8.03	0.7995	-0.0213	0.0994
53	1.171	0.738	7.76	0.7371	-0.0332	0.1001	0.750	9.03	0.7208	-0.0311	0.1142
54	1.170	0.739	8.78	0.7126	-0.0544	0.1229	0.751	10.00	0.6967	-0.0519	0.1356
55	1.171	0.739	9.78	0.6993	-0.0627	0.1423	0.751	10.98	0.6837	-0.0601	0.1541
56	1.171	0.737	10.77	0.7020	-0.0727	0.1617	0.749	11.97	0.6865	-0.0700	0.1734

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
21	1.160	0.784	-2.59	-0.2829	-0.0471	0.0175	0.801	-3.08	-0.2751	-0.0442	0.0194
22	1.156	0.784	-1.86	-0.1144	-0.0408	0.0174	0.801	-2.06	-0.1112	-0.0380	0.0174
23	1.158	0.783	-1.02	0.0052	-0.0388	0.0137	0.800	-1.02	0.0051	-0.0361	0.0134
24	1.163	0.784	-0.22	0.1244	-0.0396	0.0127	0.801	-0.01	0.1210	-0.0369	0.0129
25	1.155	0.784	0.58	0.2310	-0.0370	0.0130	0.801	0.97	0.2246	-0.0343	0.0143
26	1.155	0.783	1.39	0.3570	-0.0363	0.0164	0.800	2.00	0.3472	-0.0336	0.0197
27	1.158	0.782	2.18	0.4728	-0.0341	0.0220	0.799	2.99	0.4598	-0.0315	0.0279
28	1.158	0.783	3.04	0.5586	-0.0327	0.0321	0.800	4.00	0.5432	-0.0301	0.0404
29	1.161	0.783	3.91	0.6361	-0.0360	0.C465	0.800	5.00	0.6186	-0.0333	0.0571
30	1.158	0.782	4.81	0.6973	-0.0374	0.0617	0.799	6.01	0.6782	-0.0347	0.0744
31	1.158	0.782	5.84	0.6932	-0.0339	0.0761	0.799	7.03	0.6742	-0.0313	0.0883
32	1.160	0.783	6.76	0.7423	-0.0435	0.0962	0.800	8.03	0.7218	-0.0407	0.1100
33	1.160	0.784	7.73	0.7428	-0.0442	0.1118	0.801	9.00	0.7222	-0.0414	0.1253
34	1.161	0.783	8.78	0.6999	-0.0593	0.1294	0.800	9.98	0.6806	-0.0562	0.1408
35	1.163	0.784	9.85	0.6570	-0.0652	0.1448	0.801	10.97	0.6388	-0.0619	0.1542
36	1.163	0.784	10.84	0.6609	-0.0759	0.1625	0.801	11.97	0.6426	-0.0724	0.1717

GAFOPH AEROFOIL

TRANSITION FREE

		CORRECTED					UNCORRECTED				
SER	REYN	MACH	INCID	LIFT	PITCH	DRAG	MACH	INCID	LIFT	PITCH	DRAG
2	1.191	0.825	-2.55	-0.2925	-0.0298	0.0334	0.850	-3.06	-0.2816	-0.0265	0.0349
3	1.191	0.825	-1.82	-0.1187	-0.0409	0.0299	0.850	-2.03	-0.1143	-0.0373	0.0295
4	1.188	0.825	-0.99	-0.0038	-0.0404	0.0281	0.849	-1.00	-0.0037	-0.0368	0.0273
5	1.191	0.825	-0.16	0.0740	-0.0369	0.0276	0.850	-0.04	0.0712	-0.0334	0.0270
6	1.188	0.825	0.74	0.1522	-0.0335	0.0275	0.850	0.99	0.1465	-0.0301	0.0274
7	1.193	0.826	1.61	0.2332	-0.0338	0.0318	0.851	2.00	0.2244	-0.0303	0.0324
8	1.191	0.825	2.42	0.3336	-0.0368	0.0373	0.850	2.98	0.3212	-0.0333	0.0394
9	1.193	0.826	3.25	0.4366	-0.0436	0.0479	0.851	3.99	0.4202	-0.0399	0.0519
10	1.188	0.824	4.08	0.5326	-0.0494	0.0604	0.848	4.98	0.5130	-0.0456	0.0667
11	1.193	0.826	5.00	0.5922	-0.0523	0.0757	0.851	6.00	0.5708	-0.0483	0.0834
12	1.191	0.825	5.96	0.6145	-0.0441	0.0878	0.850	7.00	0.5916	-0.0404	0.0959
13	1.193	0.825	6.90	0.6461	-0.0449	0.1021	0.850	8.00	0.6220	-0.0411	0.1110
14	1.191	0.825	7.78	0.7184	-0.0582	0.1238	0.849	9.00	0.6918	-0.0541	0.1349
15	1.191	0.825	8.73	0.7529	-0.0661	0.1412	0.849	10.01	0.7250	-0.0618	0.1532
16	1.193	0.825	9.87	0.6799	-0.0705	0.1530	0.850	11.02	0.6546	-0.0660	0.1617
17	1.191	0.825	10.81	0.6869	-0.0843	0.1701	0.850	11.97	0.6613	-0.0795	0.1786

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